FALL 2022

An Evolution Toward Planetary Engineering

Or how to save us from ourselves using simple tools and concepts

PTJ NORTH

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Why I wrote this book

My nickname is Pluto. If this book echoes with people, I will gladly expand it. If nothing echoes, it is at least a catharsis for my soul and sanity.

The decline and fall of the American Industrial Economy has been painful and apocalyptic for many good people of the United States. This decline and fall has been largely hidden or obscured by too many news bites, eternal wars, and now populist politics.

How I came to write this book is important to me and those events will help you understand it.

This is a work of fiction but for many it will echo as the truth being told. Whether this is fiction or fact is your choice. Freedom of choice for deciding fiction or fact is supported by our Constitution as I understand it but I could be wrong. In no instance is your choice my fault.

You will also see reference to “insights” mostly in my notes section on a summary topic. Insights referenced what I thought were unique or logical extensions of thoughts I made regarding that topic that others had not mentioned. I further thought these insights might have value if properly developed and packaged by a well-resourced team for commercial sale to a third party.

This book is also about a journey of thought by me alone during the recent pandemic. It reflects my life experiences of the last 12 or 13 years from a broad perspective and then less broadly the progression of my work from Spring 2020 till early 2022 which I regard as my last works. These last works could not have

been done without the absence of outside distractions that the pandemic provided.

In all those last works I was attempting to research and then adapt existing technology or materials or research and use them in new ways. I do thank the SBA' PPP program for funding the work while I looked for a paying gig during the pandemic.

Working alone on a complex and dynamical problem like climate change mitigation can allow a person to see things clearly if you pay attention long enough. Having an analytical mind is certainly helpful as well. Also having a deep background in mitigating environmental issues was certainly helpful as well. Knowing that I could absolutely not see all aspects of this broad issue forced me to set up knowledge boundaries that I would not stray beyond.

So, without further ado, here it is.

ON THE ETHICS OF PLANETARY ENGINEERING

Publication dates: 9/17/21-6/11/2022

Synopsis

Ethics is only occasionally discussed or debated in science and almost never in engineering. I suggest that it should be discussed frequently before significant scientific, or engineering developments are published or are used. The simple phrase “should we” and the word “why” need to be deliberated properly each time or we may find ourselves as a global society living in a dystopian paradise without end. This summary report addresses this perspective with several quotes by others and some modest derivative statements by me.

Introduction

I have spent most of the past five years trying to address global climate change from a mitigation technology and subsequent sustainability perspective. This effort on my part derived in large measure from my own experiences solving industrial contamination problems using innovative mitigation technologies and integrated systems over a career spanning 40+ years.

Further, during this latest endeavor, debating whether global climate change was fact or fiction did not enter my pursuit decision. I assumed it was real because I was told to do so. In time I too believed the science and knew it was real and a clear and present danger to our planet. What I didn’t then and still don’t know was its potential severity or when it might start or end. Time and others’ efforts revealed those realities to me. Global climate change’s reality will be severe, and

it has already begun. I had hoped it's effects would be linear and predictable. Those effects have been proven to be chaotic and unpredictable. Its duration will be long from a human society perspective and will likely last for centuries and more likely millennia. Human society and our global biota may not survive its effects.

Combating those effects will require a unified global effort on a scale human society has never imagined. Mitigating or reversing those global effects will be difficult at best. At worst, if nothing significant is done on a global basis, we could experience an extinction level event for ourselves and every living thing around us. This is a worst-case reality that I refuse to accept.

Progressively and starting several years ago, I began to fully appreciate the sheer scale of the issues and understand that their "knock on" or unintended consequences are appreciable and if not properly addressed beforehand they too could be catastrophic and additive to the rapidly emerging nightmare of global climate change.

Geoengineering, planetary engineering, and terraforming as terms began to be a "thing" about then as well on social media. Nobody, and I mean nobody, grasped what would be needed to even begin to address global climate change in a meaningful way. It seemed and still does seem that the human mind or its collective societies hasn't grasped the concept. I refuse to believe that we cannot grasp this concept. We simply must grasp it and learn to live and work with it.

How that is made to happen is thankfully up to others I do not now know and will likely never meet.

My summary topic reports have addressed many of the facets of global climate change mitigation and its supporting technologies. I say technologies because I realize that technical solutions properly applied will mitigate or largely solve or at worst control the effects of global climate change so that human society and our global biota can survive in some sense. Organic solutions while attractive from an uninformed perspective will not and cannot address planetary scale issues in anything other than geologic timescales of megayears.

The topic of ethics regarding planetary engineering may seem unimportant or irrelevant. It's not. If we had carefully weighed, with foresight, which is not a reliable human societal perception, our reliance on a hydrocarbon based global society, this issue of global climate change might have been avoided. That milk has been spilt forevermore unfortunately. Now we must solve the problems that decision caused.

Background

As is often the case for me, I rely on others to provide background for my design concepts, conclusions, and assorted notes. This report on ethics will not have design concepts or notes because they have been done already. Conclusions are the objective of this report. Avoiding unintended consequences for our first global or planetary engineering project(s) requires some level of ethical rigor as well.

First, a reasonable short explanation of ethics done by another will serve to establish some basic background is below.

An excerpt from: Sidgwick, Henry. *The methods of ethics*. Good Press, 2019.

“Ethics is sometimes seen as directed to the true moral laws or rational precepts of conduct, and sometimes as an inquiry into the ultimate end of reasonable human action—the good or ‘true good’ of man—and how to achieve it. Both views are familiar and will be carefully considered; but the former looms larger in modern ethical thought and is easier to connect with modern ethical systems generally. For the *good* investigated in ethics is limited to good that is at least partly attainable by human effort; so, knowledge of the end is sought to discover what actions are right for achieving it. Thus, however prominent the notion of an ultimate good may be in an ethical system, and however we interpret this notion, it won’t be any use to us unless we can discover some rules for telling us how to behave.

On the other hand, the idea of ethics as an investigation of man’s ‘ultimate good’ and how to achieve it doesn’t easily connect with what I’ll call the ‘intuitional’ view of morality—the view that conduct is right when it conforms to certain precepts or principles of duty that are intuitively known to be unconditionally binding.”

So, from my perspective, what better “ultimate good” can we pursue than our global biota’s survival? We do also have a unique opportunity to determine now, deliberately, what steps we must take to achieve that survival.

A perspective by another worth review is below.

An excerpt from: Moores, John, and Stela Melo. "Radiative Processes in Terraforming." *Undergraduate Article* (2003).

“It was not so long ago that the civilizations of the world were isolated from one another by the vast distances between them. However, whether lured by the prospect of economic gains, or forced by the pressures from within, these civilizations were forced to expand, taming the lands and oceans which separated

them. As a result, these islands of civilization have merged and now encompass islands of wilderness on our finite globe."

Decisions got made from limited perspectives most assuredly and we've now got what we have. Changing that perspective and driving toward a plan to change our future seems like it's a requirement for our survival.

A definition worth review by another is below.

Another excerpt from: Moores, John, and Stela Melo. "Radiative Processes in Terraforming." *Undergraduate Article* (2003).

"Let us begin by defining terraforming as *the intentional application of anthropogenic forcing to a planetary environment to effect a desired climactic change*. This can be viewed as global environment engineering and as such may require substantial maintenance even in steady state. Many of the methods of terraforming are broadly applicable and may be used in the context of any planetary body with an atmosphere, oceans, or other radiative sinks. As well, the lessons of this thought experiment are applicable not only to other planets, but also to the earth (for instance to avoid the recurrence of a 'snowball-earth' event or a catastrophic 'run-away greenhouse' effect).

Another item which should be kept in mind during this paper is the magnitude of the quantities involved. Naturally, the energy and mass transport required to remake the climatology of a planet are immense and as such in the early part of the space era (early 1950s to mid 1970s), terraforming was largely the domain of science fiction.

The methods used to change a planet's atmosphere and eventually alter its ecosystem are not perfectly understood by scientists today, even on Earth. Yet as the issue of climate change on Earth has shown, humans have a very great impact on the planet they inhabit. It is not a large step beyond this to consider attempting this interference purposefully."

It becomes obvious, I think, that using the term planetary engineering or "terraforming" begins to make better sense when an appreciation of the sheer

scale of the endeavor becomes commonly accepted. Global climate change mitigation is just another facet of planetary engineering or terraforming. An unintended consequence of living on a damaged planet I would guess.

We have also been given a gift which we as a broad audience are just now beginning to understand is described just below.

An excerpt from: McMichael, Anthony J., and Tony McMichael. *Planetary overload: global environmental change and the health of the human species*. Cambridge University Press, 1993.

“It is not surprising that there are no locales in space yet discovered which are habitable. Humans live within, and are part of, the Earth's biosphere which can be viewed as a biogeochemical life-support system englobing the planet and extending from the top of the atmosphere to substantial depths within the crust. There are no other Earths in the Solar System which duplicate these conditions and they would already be inhabited by some sort of life if there were. Thus, the challenge of space settlement involves the creation of artificial and autonomous biospheres which can resist or adapt to local barren conditions. Here we have the reason why settlement lags at least four decades behind travel and remains to happen: the science of life-support systems is much more complicated and poorly understood than rocket science.

Nevertheless, space remains an energy and material rich frontier and there have been several technical assessments of space as an arena for human endeavor since the dawning of the Space Age. The most well-known of these are the proposals of O'Neill and followers in the 1970s which involve the fabrication (from lunar or asteroid materials) of large orbiting habitats, spun to create artificial gravity and landscaped on the interior, providing a quasi-natural environment. Originally, it was envisaged that these habitats would house workers building solar power satellites for Earth. But if the initial operations could be made to pay, it was natural to predict the more self-sufficient of these orbiting city states adopting a more independent course and moving away from the environs of Earth altogether. Humanity would have evolved into a spacefaring civilization.”

Another perspective by others from some decades ago is below.

An excerpt from: Michaelis, Anthony R. "Global warming needs planetary engineering." *Interdisciplinary Science Reviews* 14, no. 4 (1989): 321-330.

“Our planet is slowly warming up because of our overindulgence in fossil fuel energy. This scientific fact is known and accepted by politicians and public alike. The profligate combustion of fossil fuels, giving rise to ever-increasing amounts of carbon dioxide, has produced the Greenhouse Effect by preventing radiation into space of the heat generated on Earth. This is nothing new: it began when the first caveman lit his wood fire. However, today's massive combustion is leading to a gradual warming of the Earth, an irreversible phenomenon. There is no known way of cooling the Earth, nor can the oceans' levels be lowered once the polar icecaps and glaciers have started to melt in earnest. To arrest the Greenhouse Effect here and now would mean stopping all oil-driven transportation and extinguishing all fires under the boilers of fossil-fueled power stations. Without motor cars and without electricity, our present civilization would cease to exist. We have caused a deterioration of our planetary environment that cannot be made good again. At present the size of the Greenhouse Effect and its time scale are not yet accurately known, and the best available estimates postulate a temperature rise of 1.5 to 4.5 °C over the next 50 years. Alternative energy sources, renewable, carbon-free, and unlimited, are provided by nature and will be considered in some detail below. However, all these are still in the future and, where already used, are circumscribed by quite inadequate financial and political support. Global warming affects the whole Earth, and only planetary engineering can provide a solution if it is now seriously undertaken.”

Without meaning to be too boring yet another perspective is below.

An excerpt (various sources but likely) from: Todd, Paul. "Planetary biology and terraforming." *Gravitational and Space Research* 19, no. 2 (2007).

“A variety of claims have been made concerning the future of ecopoiesis (starting an ecosystem) and terraforming (creating an earth-like environment) – highly controversial subjects. Planetary protection is a significant component of the ecopoiesis debate. One of the significant outcomes of performing research in this area is expected to be the informing of a scientific community consensus concerning these subjects.

Today's thinkers hold varying opinions concerning ecopoiesis, the process of evolving a physical and biological environment that can lead to "terraforming" – the deliberate introduction of terrestrial-type ecosystems on remote celestial bodies such as planets, moons, and asteroids (Haynes, 1990). On one extreme, principles of planetary protection prohibit the introduction of any living organisms onto Earth's neighbors in the solar system while, on the other extreme advocates of terraforming propose the early modification of Mars (for example) to initiate processes that will make the planet a more hospitable place for humans should they decide to go there (Zubrin and Wagner, 1996). Either way, knowledge is lacking, and experimental testing is non- existent, related to the basic understanding of the ecopoiesis process. Since the implementation of any concepts related to ecopoiesis would occur several decades in the future, the experimental study of ecopoiesis now would seem an ideal objective. While ethical considerations are outside the scope of this presentation, such a research program could inform this debate.

It is of great value to cause the visions of the prophets of the field to be extended an entire century forward. Meanwhile, a series of benign, but difficult experiments (laboratory, field, and theory) can and should be performed. The undertaking of ecopoiesis/terraforming research can be considered a direct response to the challenge originally put forth by Christopher McKay and the late Robert Haynes: "if it is decided to implement such a program of planetary engineering, a slow and conservative approach is essential. Sufficient time must be allowed for a wide range of studies of Mars as it exists at present, and for careful planning, modeling and 'pilot-plant' trials (where possible) of all successive steps in the enterprise." (Haynes & McKay, 1995). This challenge calls for research that includes biological experiments and theoretical modeling directed at the implementation of the enabling notions in terraforming offered by Fogg (1995), McKay et al. (1991), and Boston and Thompson (1991) among others. To date, only individual components of ecopoetic systems have been investigated – a few species of microorganisms and certain primitive and vascular plants.

As mentioned earlier, terraforming requires an immense amount of time and resources. The first step of extraterrestrial global warming requires the presence or introduction of greenhouse gases on the surface of a target planet. Once these needed gases are present in ample amounts, the process of global warming can

take up to 100,000 years to raise the surface temperature above water's freezing point. Once this temperature is achieved, the next step involves introduction of Earth species for oxygen production. While some organisms that can tolerate low temperatures can be introduced before the desired temperature is reached, most organisms would have to wait. Depending on the size of the planet, an incredible number of photosynthetic organisms would have to be transferred from Earth to the target planet for oxygen production. Even with an ample number of organisms, it would take around 100,000 years to produce enough oxygen to reach the needed concentration of atmospheric oxygen for human survival.

Another issue arises when looking at suitable planets for terraforming: the possibility of life already existing on the planet. Because planets suitable for terraforming require an atmosphere and certain compounds to be present, the possibility of life already existing on these planets is high. This raises the ethical question of whether humanity has the right to change the atmosphere of a planet already home to living organisms to an atmosphere that would result in the death of those organisms (Schwartz, 2013). The speed and scale at which this change is induced would not allow for adaptation of these organisms, and ultimately lead to their extinction."

We have a unique opportunity in front of us. If we are deliberative and inclusive as a global society, we can largely mitigate and control the effects of global climate change. The ethics or politics of this planetary engineering project must be fully understood and adopted by our global society, or it will fail. No one country or even a large set of countries can do this project on their own. It is too large, too complex and if not approached with a solid but adaptive plan that is properly financed and researched it will fail. Above all else, before any important decisions are made, ask "should we" and "why" and drive for clear answers.

PLANETARY ENGINEERING SCALED FUNDING MODEL

Publication dates: April 10, 2018 -April 20, 2021

Synopsis

Funding planetary scaled projects has been largely ignored till now. This is probably because no one knows or knew how much each mitigation technology might cost to implement and operate. Blindly relying on private or public funding sources to magically appear seems naïve. Early on in my studies and development of climate change mitigation technologies I recognized this need. It didn't take much effort to realize no one knew much either unfortunately.

My original focus on funding was targeted on developing USDOD funding sources for development of these technologies albeit at much smaller scales.

This model resulted from an "aha" moment by me that I immediately roughed out and reported upon. Much later I learned that a similar effort had been done in the 1990's but with much less thought (I think) by the US government.

Later yet, I adapted that early model of mine to fund global or planetary scaled projects which would need several trillion $USD to properly research, develop, design, install and operate. All mitigation technologies being mutually beneficial and all needing to be done simultaneously.

That model is outlined below.

Introduction

"Conventional infrastructure funding can't work for planetary scale projects."

Infrastructure and its various components, whether it be roads, bridges, dams, telecommunications, and climate change mitigation technologies are required for any society to be successful on a go forward basis. History documents societies that failed by not providing just one of those infrastructure components.

Logically, then, all components must be provided on an ongoing basis or government must squarely face the high probability of a catastrophic societal collapse. In a rapidly globalizing world this could be even worse.

We are citizens of the most globally advanced society with no qualification. Maintaining that qualification requires that we find new ways to fund infrastructure development with input but little monies from government. Why that statement is true is simple. Government rises, falls, and changes through time but the need for useable and sustainable infrastructure never changes.

"Strength lies not in defense but in attack. Attack the problem."

Infrastructure is the backbone of society. Without its continuous development and support society cannot thrive and without it fails badly. Infrastructure therefore requires consistent funding that cannot be stopped or interrupted, or the society will likely fail.

Planetary engineering is simply very large-scale projects that are designed to support the resolution of problems caused by other infrastructure needs that support a global society. Put another way, planetary engineering is the application of technology for the purpose of influencing the global environments of a planet.

Its objectives usually involve increasing the habitability of other worlds or mitigating decreases in habitability on Earth. How we design and fund planetary scale projects therefore is needed at least as much as roads, bridges, power grids and a safe potable water supply. It is the subject of this simple paper.

Funding

Planetary scale infrastructure projects like Direct Air Carbon Capture (DACC) can be funded from a tax source that has never been exploited. This tax source can be exploited by any government:

Energy Consumption

Energy consumption is now tracked by the U.S. Energy Information Administration which is part of the U.S. Department of Energy. Energy consumption is reported as units of “Btu consumed” and usually in blocks of 1000 Btu.

Notes

- An energy consumption tax would be collected in $0.01 / 1000 Btu “blocks” as they are “consumed” or similar.
- A carbon removal award would be paid in $5.00 / ton “blocks” as they are “removed” or similar.

- The energy consumption tax would equal roughly $10 Trillion / year if taken on a global basis.
- The carbon removal award would equal roughly $7 Trillion / year if taken on a global basis.
- The balance of these taxes and awards for energy savings could be spent on more mundane but necessary infrastructure uses such as roads, bridges etc.
- These taxes and awards would be collected daily from local / county / state and federal sources on a global basis.
- This tax “pool” would need to be protected from theft, money laundering, inflation or deflation or appropriation.
- Protection from these would require both cybersecurity and the tax pool funds converted to a “pool” of “coin”. A “coin” would be a unique cryptocurrency encrypted and protected by cybersecurity.
- Cybersecurity would be funded from the “pool”.
- Accruing the value of “coin” in the “pool” is important especially as energy consumption declines.
- Cryptocurrency for this "pool" would therefore have a finite or fixed number of "coins" available for distribution into qualified projects.
- Accepted and qualified projects would have "coins" converted to USD or other fiat monies to purchase goods and services for the "project".
- Incentives for demonstrable energy savings (some multiple ranging from small to large) would be offered and paid as incremental “coin” for projects that save "energy" both during construction and over its lifetime.

- Said incentives would be paid out both on an anticipated and incremental time basis.
- Protection would need no oversight except cybercrime prevention.
- Coins increase in value as energy "savings" occur due to the limited number of coins.
- A small number of new coins can be created by “block chain mining” or as incentives realized for energy budget consumption reduction.
- The total value of the coin "pool" would accrue rapidly and likely exceed some very large $ amount in Yr1 let alone Yr10.
- A sovereign cryptocurrency avoids inflation or deflation risks, acts of God, money laundering, or theft risk etc. Trading between this cryptocurrency and others would be forbidden.
- A founder (whoever that turns out to be) keeps a set minimum number of coins. As coins are "added" or the pool value grows they can be converted to any fiat money either individually or as a block.
- Development of sufficient cybersecurity to ensure the integrity of the pool could be seen as infrastructure. This cybersecurity need not be limited to only uses pertaining to the pool.
- Energy transmission and its related infrastructure could be included or by extension it's cybersecurity and integrity.
- Water treatment and its distribution and food (although food would be a conceptual "stretch).
- Roads, bridges, dams, levees, traffic lights, toll booths etc would be funded.

- Also, nextgen data transmission networks (5G or later) could be funded and maybe should be funded since they seem to be "evergreen".
- Atmospheric carbon stripping via DACC and its permanent removal from the carbon cycle should be included as well.
- Also, Oceanic Alkalinity Enhancement and associated measures should be included.
- The conversion of line or single crop agriculture to regenerative methods could also be included.

PLANETARY ENGINEERING SCALED DIRECT AIR CARBON CAPTURE

Publication dates: 8/5/2019 - 6/20/22

Synopsis

This work began in early 2018 and I first published a version of it in August of 2019. The original design concept was done by me alone but was paid for by a second party. No questions were ever asked by that party, so I have no idea if they even read it. No matter really.

Iteratively in the following years as I had further thoughts and insights which I published as a succession of versions mostly involving rather complex air separation and cryogenic distillation technologies. Given that I had many other projects to work on this was really a part time endeavor. All versions focused on at scale removal of atmospheric carbon and making the “system” self-powering and creating a solid carbon precipitate suitable for direct disposal.

The last iteration or version I value engineered to drive out materials expense and cost of operation. I also went to another level of detail calculating efficiencies and siting information. This design belongs in the public domain. I doubt that private enterprise could cash flow their construction. Operation and maintenance quite possibly but not construction.

Introduction

A reasonable summary of the scale of atmospheric carbon in our atmosphere and why it must be removed as stated by others is below.

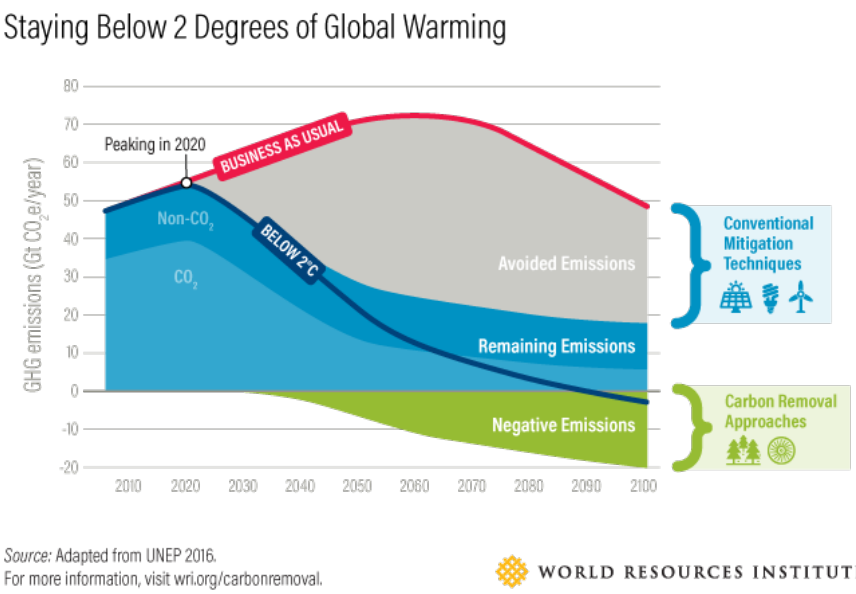
An excerpt from: Hannah Ritchie, Max Roser and Pablo Rosado (2020) - "CO_2 and Greenhouse Gas Emissions"

“Since the Industrial Revolution, humans have emitted more than 2,000 gigatons of carbon dioxide into the atmosphere. (A gigaton is one billion metric tons.)

This thickening blanket of heat-trapping greenhouse gases is the cause of the global warming we are experiencing today. If nothing changes, climate impacts such as forest fires, stifling heat waves and damaging sea level rise will only continue to intensify.

The imperative for combatting climate change is to dramatically curb carbon emissions—for example, by ramping up renewable energy, boosting energy efficiency, halting deforestation, and curbing super pollutants like hydrofluorocarbons (HFCs). The latest climate science tells us, however, that these efforts alone aren’t enough to prevent dangerous climate change. To keep global temperature rise to less than 1.5-2 degrees C (2.7-3.6 degrees F), the limit scientists say is necessary for preventing the worst climate impacts, we’ll need to not only reduce emissions, but also remove and store some carbon from the atmosphere [4]. **In fact, most climate scenarios show we’ll need to remove billions of metric tons of carbon dioxide annually by midcentury, while also ramping up emissions reductions.**

Carbon removal can take several forms, from new technologies to land management practices. The big question is whether these approaches can deliver carbon removal at the scale needed in the coming decades.



Note: This is a notional scenario consistent with an at least 66 percent chance of limiting global warming to below 2°C. Some residual gross greenhouse gas emissions (both CO2 and non-CO2 such as CH4 or methane) will remain at the end of the century even with ambitious climate action because they are too difficult or costly to remove entirely. Once negative emissions exceed those that remain net zero emissions are reached. Faster and/or deeper emission reductions could reduce the role for carbon removal; slower and/or weaker emission reductions would increase the need for carbon removal."

This author: Forests and farmlands make for ready but very temporary removal of atmospheric carbon. Oceans offer the same temporary removal solution. A permanent solution would be the removal of atmospheric carbon on a very large scale and "fixing" the carbon (largely CO2 and methane) that removes it completely and permanently from the carbon cycle. I do believe there is a viable and practical path to accomplishing that task. It's quite simple in concept – take the methane, concentrate it from the air and then combust it for power generation. Take both its combustion products (mostly CO2) and stripped atmospheric CO2 and fix it permanently by dissolving the CO2 in water and then allowing basalt (rock) to mineralize it in a permanent fashion as "limestone" or

“dolomite”. There is a way to do this – it’s not new science. It’s just never been done at this proposed scale before.

Concept

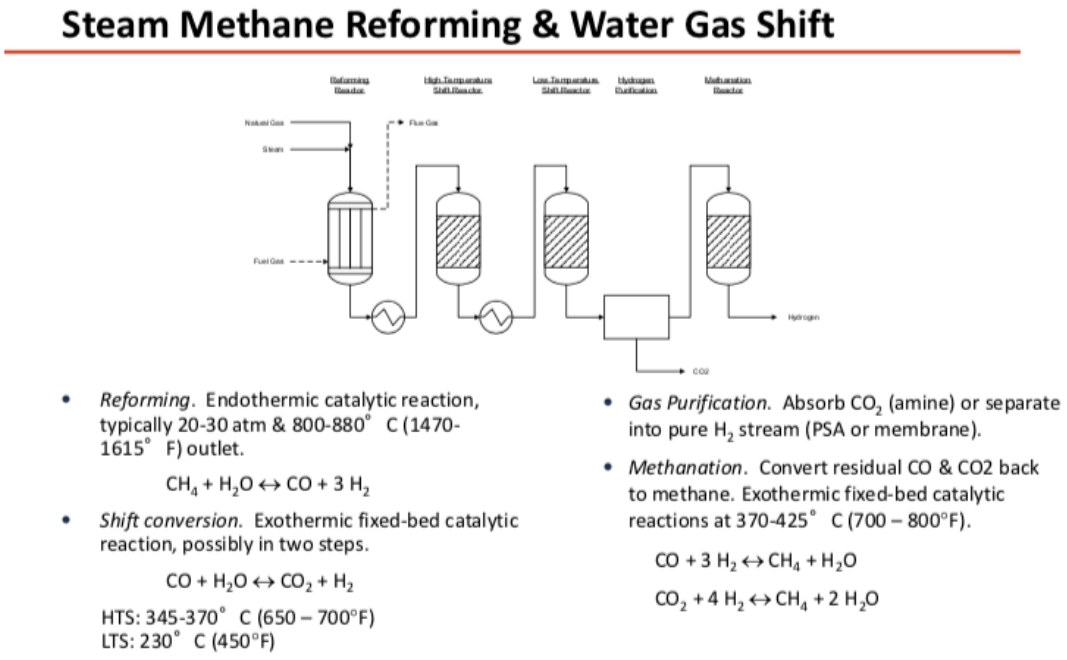
This process will take a lot of power to make it happen on any meaningful scale but will, in balance, with the other proposed renewable energy sources applied to it would be self-powered with a likely excess “dumped” to an external power grid. In all instances, any form of “emission” would be only water vapor. In all instances all processes are well proven. No new technology is required. But again, this removal process permanently removes, at a planetary scale atmospheric carbon, through potentially thousands of installations, using only renewable energy power and produces no pollution at all.

First, remove atmospheric water vapor in a series of large-scale venturi’s which would collect and use the now condensed water for process needs or discharge its very large volume of fresh water to external sources. The venturis would have wind turbines mounted in their throats to provide a primary source of process power and to provide motive flow through the venturi’s. No pollution at all.

Then take the molecular sieve separated methane and carbon dioxide, remove, and then concentrate them from the raw but now dried atmospheric influent. In an integrated methane reformer make concentrated hydrogen gas and a nicely separated carbon dioxide gas stream suitable for compression, tank storage and subsequent deep well injection for permanent fixation as an insoluble carbonate rock mineral.

A description by others of a methane reformer is below.

An excerpt from: Schaschke, Carl. *A dictionary of chemical engineering*. OUP Oxford, 2014.


Steam Methane Reforming & Water Gas Shift
Reforming Reactor
High Temperature Shift Reactor
Low Temperature Shift Reactor
Hydrogen Purification
Methanation Reactor
Natural Gas
Steam
Flue Gas
Fuel Gas
Hydrogen
CO2
• Reforming. Endothermic catalytic reaction, typically 20-30 atm & 800-880° C (1470-1615° F) outlet.
CH4 + H2O ↔ CO + 3 H2
• Shift conversion. Exothermic fixed-bed catalytic reaction, possibly in two steps.
CO + H2O ↔ CO2 + H2
HTS: 345-370° C (650 – 700°F)
LTS: 230° C (450°F)
• Gas Purification. Absorb CO2 (amine) or separate into pure H2 stream (PSA or membrane).
• Methanation. Convert residual CO & CO2 back to methane. Exothermic fixed-bed catalytic reactions at 370-425° C (700 – 800°F).
CO + 3 H2 ↔ CH4 + H2O
CO2 + 4 H2 ↔ CH4 + 2 H2O

The thus purified “filtrate” for the first molecular sieve (MS1) is blower transferred to a second molecular sieve (MS2) which separates nitrogen from the remaining atmospheric gases. Said nitrogen stream is then vented to atmosphere with no ill effect or by proper piping, valving and controls it is used to “strip” its molecular sieves of captured gases and return them to a ready state in a controlled manner.”

The filtrate from MS2 would be an enriched or concentrated oxygen product suitable for compression, tank storage and then careful combustion as an accelerant with the methane reformer’s compressed and tank stored enriched hydrogen product.

A parallel process but closely integrated air separation unit (ASU) would then cryogenically make liquid oxygen (LOX) and liquid nitrogen (LN2) with its excess vented harmlessly to the atmosphere with other process off gases such as excess

to need oxygen and some very small amounts of NOx from the expanding gas turbine power generation plant.

As just previously mentioned the hydrogen and oxygen products would then be combusted in an expanding gas turbine spun to make power for use within the facility. Excess heat would be recaptured to optimize power generation or to help drive the heat exchange of another power source – geothermal power. No pollution at all.

The geothermal power process would most commonly be hot dry rock using as a heat transfer medium supercritical CO2 which when compressed and liquefied and pumped downhole on a recirculating basis would act as an effective heat exchange liquid. Some small volume of the liquid CO2 would react with the surrounding hot dry rock forming in-situ precipitate carbonates (permanent carbon removal). This power generation process produces nothing but water vapor. No pollution at all.

A simple sketch and associated text by others with its own citation that explains this concept is below:

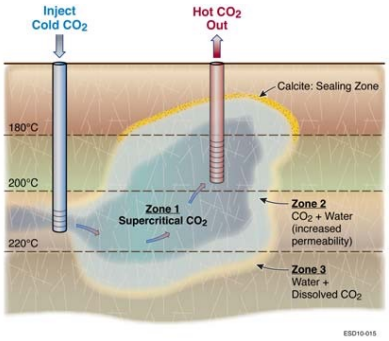


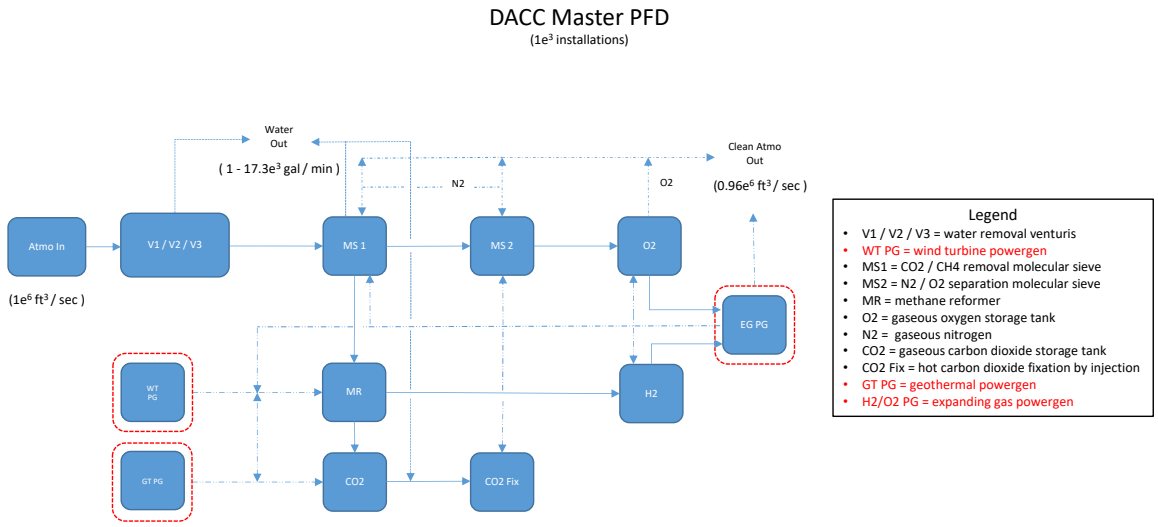
Figure 1. Schematic of the three zones created by injection of CO_2 into hot fractured rock (after Fouillac et al., 2004; Ueda et al., 2005).

"The peripheral zone (Zone 3) of an EGS operated with CO_2 may experience a combination of mineral dissolution and precipitation effects that could impact reservoir growth and longevity. The long-term behavior of this outermost zone will be crucial for sustaining energy recovery, for estimating CO_2 loss rates, and for figuring tradeoffs between power generation and geologic storage of CO_2. We have performed reactive geochemical transport simulations to study CO_2 induced mineral alteration in the outer zone, estimating associated changes in reservoir porosity, and sequestration of CO_2 by secondary carbonate precipitation."

Next, then take any other excess CO2 and fix it permanently by dissolving the CO2 in water (it can be seawater, freshwater, or highly contaminated groundwater

btw) and then allowing basalt (rock) to mineralize it in a permanent fashion as “limestone” or “dolomite”. There is a way to do this – again, it’s not new science. But again, no pollution at all.

A simple master process flow diagram that captures all the above and was drafted solely by the author (insight) in late June 2022 is below:



A look at a modest but not scaleable first step that is being proven now by ClimeWorks (www.climeworks.com):

12.10.2017

At Climeworks, we are searching for solutions to unlock a negative emissions future. After years of hard work and research, we have developed a patented technology which is now in action at the world’s first commercial Direct Air Capture (DAC) plant in Switzerland. Recently, we’ve been working on a different plant – and it’s another world first…
We are excited to announce that we are combining safe and permanent geological storage with our highly scalable carbon removal technology through direct air capture of CO_2. The pilot plant is part of the CarbFix2 project which stores the air-captured CO_2 safely and permanently in basalt, leading us closer to our efforts to achieve global warming targets.

CarbFix2 has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 764760 and is led by Iceland's multi-utility company Reykjavik Energy. The collaborative research project centres around one of the world's largest geothermal power plants in Hellisheidi, Iceland, where CO_2 is currently injected and mineralized at an industrial scale.

Basalt core containing carbonates – Photo by Sandra O Snaebjornsdottir

Notes

- Climate change is beginning, and we are past the tipping point.
- Atmospheric carbon removal is crucial to slow or stop climate change.
- Industrial scale solutions cannot be scaled sufficiently to affect its major driver - atmospheric carbon accumulation and all its derivative issues.
- Terraforming is the most likely concept that grasps what must be done.
- Science fiction must become science fact with no chance of "do overs".
- Mission Impossible must be mission fact.
- No new science or physics, no new chemistry, no “unobtainium” allowed - we have no time.

- The Apollo program will be tinker toys in comparison.
- Where the money comes from is not my problem.
- Where the staff comes from is not my problem.
- Where the materials come from is not my problem.
- The concept, its design, operating conditions, and general locations are my problem.
- Page 12 process flow diagram is the property and discovery by and of this author (insight).
- Press / temp precip driven (50 bar and 100C) (insight).
- Block precipitation of carbonate (insight).
- Series atmo and precip process.
- 70% venturi efficiency is OK if done in series as the venturi's are pictured (insight).
- Altitude placement critical – likely more than 2000 meters (insight).
- Syenite (basalt) location critical for carbonate precipitation.
- RE sources critical
    - Wind
    - Geothermal
    - Lightning (harness the lightning and no pun) (insight).
    - H2/O2 expanding gas turbine direct drive power generation.
- Venturi effect for H2O and dust removal (think horizontal scrubber).
- Multi step venturi effect (insight).
- Materials of construction = CIP concrete (venturi throat mount - cross supports) of at least ACI 357 grade or better.
- Controls for fixation = fe / mg or ca bleed through (insight).

- Controls for blending geothermal reinjection fluid with venturi or EGT condensate by conductivity and temperature (insight).
- Scale / sizing critical to ensure solution is effective should be done by others.
- Stacked / nest inlets and outlets are acceptable.
- Moving parts minimized:
    - Wind turbine(s) with winglets to avoid venturi erosion (insight).
    - Pumps
    - H2/O2 expanding gas turbine and power generator
    - Molecular sieve indexing segmented disc
- Planetary engineering scaled (never been done).
- Lightning rods not required, domed CIP bronze caps and rings necessary constructed of C86300 (SAE 430B) alloy at minimum (insight)
- Water effluent for crop irrigation or potable consumption as determined by others as a 24/7 flow.
- Locations ~ 1000's at a mean altitude of 8000' and oriented into a prevailing wind direction for optimal efficiency.
- Venturi throats (which will likely be 100 meters wide or more) may be lined with "ridges" of an aspect to force sudden pressure drop to force water removal and drainage (insight).
- Venturi throats (in series) may be series heated / cooled for enhanced moisture removal (insight).
- Molecular sieve materials are known (BASF' Basolite C300 etc.) – use them.
- Circular segmented "disc" sieves slowly revolving on a horizontal axis with magnetic bearings would make the separation (insight).

- Offgassing the “carbon” would be done on a segment-by-segment basis into the ASU or methane reformer as required (insight).
- Dissolution of the residual carbon dioxide would be done in a small portion of the water effluent collected from the venture throat(s) (insight).
- Saturated solutions of the dissolved “carbon” or carbon dioxide would be pumped through series plumbed “blocks” of finely ground basalt (syenite more likely) and thereby be precipitated under an appropriate temperature and pumped pressure (insight).
- Fully loaded blocks would be gravity drained then placed in underground storage (insight).
- Underground “C” storage can be backfilled basalt (syenite) ore body.
- Underground “C” storage can be dry rock contact zone margin.
- On-site milling of syenite is the most practical solution if possible.
- Milling is a wear intensive operation and will require manual oversight and maintenance.
- If constructed properly and automated correctly the “system” would only require periodic and planned maintenance.
- Process details may be covered by other of this author’s publications.
- Other, simpler, process schema such as blower / absorbent and selective membrane technology are not scaleable for at scale planetary engineering purposes.
- Other, simpler, process schema is suitable for point source mitigation purposes such as industrial and municipal applications.

PLANETARY ENGINEERING SCALED OCEANIC CO2 MITIGATION

Publication date: April 1, 2021

Synopsis

During an in-depth review of the literature in early 2021 I began to realize that oceanic CO2 removal is easily more technically complex than atmospheric CO2 removal. Why can certainly be debated and probably very hotly too. Very simply put our oceans are still mostly a mystery wrapped in a riddle to the science community. Oceanic circulation and its own chemistry and biota are also a challenge to understand let alone model with any real assurance of accuracy or repeatability. Unintended consequences of faulty modeling or just poor science or engineering can be catastrophic.

My response to this problem of “not enough” information led me outline herein below what I felt could be a path forward. It’s not an easy path by any means. Funding and access to relevant data will be a first order priority. Data may not now exist and will have to be gathered, analyzed, tested etc. Some method of continuous monitoring and feedback will also have to be invented and globally adopted. Reading this chapter will lead to more questions than answers. As it should.

Lastly, why would I advocate methane hydrate mining and oceanic alkalinity enhancement as answers for oceanic CO2 mitigation. Several reasons are outlined. But pursuing these paths simultaneously generates data and data analysis yields knowledge. Knowledge can lead to confident steps toward

mitigation while providing a much-needed societal building block with little following risk if approached properly by those business entities who can afford it.

Introduction

This report updates in a modest way my original work published in early 2021. I hope it clarifies my logic and limits I have placed on myself. I call those limits my guardrails.

Finding the way to remove and stabilize dissolved CO2 at a consistent and safe level from the world ocean represents an enormous opportunity to stabilize and reverse the rapid degradation of the world ocean' biota that cannot be ignored. Without a healthy world ocean biota all terrestrial life would rapidly end. This problem of our creation represents an existential threat.

It also represents a unique climate change carbon removal opportunity as well. Said carbon removal opportunity is certainly large enough to "budge the needle" and could largely offset the melting of arctic permafrost and its release of organic carbon into the atmosphere which is an emerging major contributor to both climate change and global warming.

I propose to remove and stabilize or "fixate" that excess oceanic dissolved CO2 in two ways. Both, taken together would largely resolve the problem on an ongoing basis. If only one is chose, then that ongoing problem resolution could be in doubt or be, at minimum, much more costly:

One: Mine the methane clathrate deposits that exist in the oceanic subsurface and use the recovered methane to make products for human use (fuel, plastics etc). As a function of solution mining the methane clathrate, we can simultaneously reform the former methane clathrate deposits into carbon dioxide

(CO2) clathrates (not new science btw) that fixes that CO2 into a stable form and remove it from the carbon cycle.

Two: Add a simple combination of very finely ground lime (CaO) and calcium carbonate (CaCO3) into limited areas of the ocean and induce a form of cascade reaction via nucleation of a course, granular limestone that would settle readily onto the ocean floor as a stable deposit with no foreseeable harm to the surrounding biota.

Both methods will work. Both will require well-resourced teams to prove up and scale up. **The profit potential from the first method is enormous – very likely on the order of USD$1x10^{14} or more spread over a 20 – 30-year span.** A very small portion of the profit from this work could be used to fund the other program which is why I advocate it despite its risks. The other is best dealt with at the governmental level and would cost a very small fraction of the first method in my estimation but without data it cannot be done safely. Data will come from the first method. Those fractional expenses and their definition should be left to a well-financed team and not me alone.

If oceanic CO2 removal by alkalinity enhance is only pursued, then I have provided a likely funding model as mentioned previously.

The scale of the overall problem is enormous. I refer to that scale as planetary engineering. Think at that scale, make considered decisions and a plan and you will conquer the problem.

An excerpt by others is below.

An excerpt from: Kalogirou, Soteris A. "Seawater desalination using renewable energy sources." *Progress in energy and combustion science* 31, no. 3 (2005): 242-281.

“As the planet's most abundant resource, seawater accounts for 70% of the Earth's surface, contributing to various natural cycles in the Earth ecosystem. One representative cycle is the water cycle, in which solar energy evaporates seawater to separate salts and water vapor, producing fresh water [1]. Another significant cycle is the carbon cycle, which maintains the atmospheric carbon dioxide (CO2) level by capturing the gas in seawater and forming carbonated materials such as CaCO3 and CaMg (CO3)2 [2]. However, the sharp increase in the world population and the use of fossil fuels have caused water scarcity [3–5] and the elevation of the CO2 concentration in the atmosphere.

According to the Worldwatch Institute, an estimated 1.8 billion people will reside in complete water scarcity regions in 2025, while almost 50% of the world's population will suffer from water stresses [6]. Additionally, the Earth is naturally able to process 14 billion tons of CO2 per year by diffusing CO2 into water or by photosynthesis by green plants [7]. However, according to the report [7], the CO2 emissions in 2050 are predicted to be 62 billion tons per year, which is more than four times the level that the Earth can handle per year.”

Another perspective is below.

An excerpt from: Wuebbles, Donald J., and Katharine Hayhoe. "Atmospheric methane and global change." *Earth-Science Reviews* 57, no. 3-4 (2002): 177-210.

"The release of methane from clathrates (sub-ocean floor deposits – this author) to the atmosphere is one of the main reasons for the periodic warming of climate. The relationship between the concentration of methane in the atmosphere (estimated from the research on ice cores) and atmospheric temperature over the last 420 000 years has been noted by Wuebbles and Hayhoe [8]. They connected the synchronic changes in temperature and the concentrations of methane in the glacial and interglacial periods with alternating periods of destabilization and stability of methane clathrate deposits identified based on geological data recording varying participation of individual carbon isotopes in the sediment."

So, what will happen in an anthropogenic climate warming situation like the one we are causing? Will it only be similar in scope to the above statement? It will be something far worse I suspect.

It's time to mine this resource and use it - rather than lose it and suffer yet more hazard. You've got to remember that I am not a tree hugger but rather a pragmatist.
This author believe he has found (circa August 2019) a unique and practical way to successfully mine this enormous hydrocarbon resource for what will very likely be least cost and least risk. This way is outlined in the "Notes" section at the end of this simple updated summary from the original report published in August 2019.

Background

I have singularly focused on the methane hydrate mining solution by assembling a long list of notes with insights. The other method of CO2 removal by oceanic alkalinity enhancement is included in the notes section as well.
Some methane hydrate references:

[1] **USGS Gas Hydrates Lab**: Stephen Wessells, Laura Stern, Steve Kirby; United States Geological Survey Multimedia Gallery Video, 2012.

[2] **A Global Inventory of Natural Gas Hydrate Occurrence**: Keith A. Kvenvolden and Thomas D. Lorenson, Pacific Coastal & Marine Science Center, United States Geological Survey.

[3] **Natural Gas Hydrates: A Review**: Timothy S. Collett, Arthur H. Johnson, Camelia C. Knapp, Ray Boswell; Natural gas hydrates--Energy resource potential and associated geologic hazards: AAPG Memoir 89, p. 146-219, 2009.

[4] **Gas Hydrates Offshore Southeastern United States**: Carolyn Ruppel, Georgia Institute of Technology, NOAA Ocean Explorer website, last accessed November 2016.

[5] **Assessment of Gas Hydrate Resources on the North Slope, Alaska, 2008**: United States Geological Survey, Fact Sheet 2008-3073, October 2008.

[6] **U.S. and Japan Complete Successful Field Trial of Methane Hydrate Production Technologies**: United States Department of Energy press release, May 2, 2012.

[7] **Energy Resource Potential of Methane Hydrate**: An introduction to the science and energy potential of a unique resource; publication by the National Energy Technology Laboratory, United States Department of Energy, February 2011.

[8] **Pure phase thermal property results: sI Methane Hydrate**: Woods Hole Science Center, United States Geological Survey, 2007.

[9] **Gas Hydrates and Climate Warming** - Why a Methane Catastrophe Is Unlikely: Carolyn Ruppel and Diane Noserale, United States Geological Survey, Sound Waves Newsletter, May/June 2012.

[10] **Study suggests large methane reservoirs beneath Antarctic ice sheet**: Tim Stephens, press release, University of California Santa Cruz, August 29, 2012.

Solution Mining Validation

Validating or rejecting the solution mining concept as originally conceived by this author in August 2019 serves as the partial basis for a prior art statement. It is not published herein.

The following statement by others partially established a basis for doing so is below.

An excerpt from: Cieślak, S. Y. L. W. I. A., and Kazimierz Gaj. "Hazards of uncontrolled methane release from clathrates analyse and environmental evaluation of extraction methods." *Environment Protection Engineering* 40, no. 3 (2014).

"In a gas exchange method (what I call solution mining - author), carbon dioxide is introduced into the clathrate deposit in a gaseous form or as an aqueous solution.

Methane occupies small and large cages in the clathrate structure, CO2 occupies only large cages, forcing CH4 out of them. It is estimated that in this way, without causing disintegration of a clathrate deposit, about 64% of the methane present in the deposit may be extracted. The reaction of CO2 clathrate formation is exothermic – formation heat is 57.9 kJ/mol. The disintegration of methane clathrate is an endothermic process – its individual dissociation heat is 54.5 kJ/mol, and thus it is lower than the formation heat of CO2 clathrate. As a result, the whole exchange process is exothermic [20]. Thus, the method is based on heating and decay of methane clathrates by the heat released during formation of carbon dioxide clathrates after its injection into the deposit of methane clathrates."

Notes:

1. Said deposits are widespread and seemingly accessible for conventional light hydrocarbon drilling access - that is very wrong.
2. Deposits are widespread but are not easily accessible due to their varied depositional environments.
3. Terrestrial deposits underlie permafrost and are normally intercalated with them.
4. Terrestrial deposits are metastable and very vulnerable to climate change warming with sudden and violent offgassing being observed.
5. Accordingly, terrestrial deposits unless deep (<100M) with a structural "cap" or structure in place (rare btw) should not be mined.
6. Proposed mining as per tar sands practices is not practical and would be very unstable and hazardous.
7. Additionally, warming terrestrial deposits will undergo rapid methanogenesis of surrounding carbon sources exacerbating the offgassing issue - meaning a wellpad or similar will not be mechanically stable or necessarily accessible or profitable for any meaningful length of time (insight).

8. Marine margin deposits are generally accessible but have the same limitations as terrestrial deposits.
9. Deep water deposits (<1000M) offer the best opportunity for successful mining with least hazard (insight).
10. Deep water deposits also are the most stable if associated with structural traps.
11. Deep water deposits offer the opportunity to use solution mining to free methane and associated light hydrocarbons from its clathrate matrix on a preferential basis (insight).
12. Climate change related warming will not be a problem for deep water deposits unless marine circulation patterns are radically disturbed which is unlikely.
13. Deep water "open" deposits do exist but should not be mined to prevent or preclude the high probability of underlying free methane and associated hydrocarbons and carbon dioxide from violently offgassing into the water column (insight).
14. Deep water open deposits would theoretically offer drag bucket mining as an option. The previous statement should preclude this in practice (insight).
15. Deep water solution mining using supercritical liquid gases such as CO2 or N2 will work (insight).
16. Not all supercritical or in-situ placed solid, or liquid or gases will work (insight).
17. The preferential gases of choice for deep water solution mining should be nitrogen and carbon dioxide (insight).
18. Trace amounts of other gases is acceptable for this application (insight).
19. Propane or butane or pentane or other similar molecules could be used but will likely not be economical (insight).

20. Deep water EOR techniques are not applicable due to intercalation (insight).
21. Wellbore casings are a requirement for this application (insight).
22. Annulus recovery of off gassed methane and other light hydrocarbons is not required (insight).
23. Specialty organic chemistry for this application is not required (insight).
24. Given the likely operating conditions for these deep-water hydrate deposits the use of liquid supercritical gases as solution mining constituents is desirable (insight).
25. All pipeline materials must be high alloy ferrous materials suitable for the application of drilling and production which may also mean the production of supercritical hot mixed liquids or fluids or phases of gases of methane, nitrogen, water, and an array of light hydrocarbons (insight).
26. Extraction pipeline (s) including gathering systems must be sized and insulated to preclude solid phase gas blockages (insight).
27. Pigging of deep-water pipelines will not be practical or useful.
28. Local supply of supercritical fluidic gases is a requirement (insight).
29. Shipboard, drilling platform or production platform must have Air Separation Unit (ASU) capacity otherwise known as air mining capabilities sufficient to include compression, combustion, heat recovery, distillation, fractionation, and molecular sieve capabilities sufficient for the application (insight).
30. Recovered methane and other associated light hydrocarbons can be transferred on shore as warm or hot supercritical fluids for further fractionation or separation and packaging (insight).

31. On board, whether ship or platform, LOX or gaseous O2 and LH2 or gaseous hydrogen, may be combusted using an expanding gas turbine for both power and heat (insight).
32. Separated and spatially separated injection and extraction wells will be required (insight).
33. Liquid supercritical nitrogen must first be injected to facilitate a "temporary" trap or cap above the deposit or liquid or supercritical gaseous nitrogen or carbon dioxide (insight).
34. Inerting the process of extraction for safety and deposit stability with a nitrogen cap for deep water methane and associated light hydrocarbons extraction is desirable (insight).
35. Enhancing the process of extraction for safety for shallow but still deep-water deposit stabilization with a carbon dioxide cap for deep water methane and associated light hydrocarbons extraction is also desirable (insight).
36. In situ replacement of carbon dioxide but not nitrogen within a reformed hydrate or clathrate matrix is desirable (insight – could be contested).
37. Mitigating climate change by "fixing" solid phase carbon dioxide in perpetuity within such a deposit is desirable (insight).
38. Mining or removing said deposits methane and associated light hydrocarbons is desirable from an onshore energy generation and refining perspective (insight).
39. Offshore distillation within its Air Separation Unit (ASU) will generate large volumes of fresh or low salinity water suitable for on board potable consumption (insight).

40. Separated liquid or gaseous phase high salinity water may be safely discharged to either the atmosphere or ocean without consequence (insight).
41. Injection wellbores must be properly sized for the application (solution mining of a metastable substance which means 2 - 3" or less) which means "small". Extraction wells can be larger bore (6 - 8") but must be grid distributed just as the injection wells.
42. This type of solution mining is new - we are not simply dissolving something; we are also allowing a clathrate / hydrate to reform in-situ with different molecules captured in its matrix (CO2) than beforehand which were methane and other light hydrocarbons (insight).
43. Simple solution mining will not yield sustainable results because most deposits are intercalated and if just dissolved with no replacement - the formation or deposit would collapse - possibly catastrophically (insight).
44. Do not lease the ASU and other powergen and heat recovery hardware - buy it to keep extraction and primary separation costs to a minimum. (Know how point)
45. Vertical wells are the best choice in this instance as per solution mining best practices. (Know how point)
46. Horizontal wells serve no useful purpose. (Know how point)
47. Fracking would be catastrophic except maybe using liquid CO2 in limited instances (tight trap). (Know how point-this author)
48. Vertical well may have an injection quill head sufficient to supply the intercalated formation with the liquid supercritical gases for some vertical depth ranging from several feet to possibly as much as 100 feet or more (insight).

49. Vertical well may have an extraction quill head sufficient to allow the intercalated formations to offgas both liquid supercritical and supercritical gases for some vertical depth ranging from several feet to possibly as much as 100 feet or more (insight).
50. Our global oceans' photic (sunlight infiltrated) zone is saturated with calcium.
51. Non biogenic CO2 is rapidly increasing.
52. Non biogenic CO2 reacts readily with non-biogenic hydrogen sources (sodium bicarbonate - NaHCO3) to form carbonic acid.
53. Carbonic acid lowers the oceans' pH.
54. Lowering the pH inhibits shell growth and disrupts food chains.
55. Adjusting the oceanic pH toward a normal value will largely restore shell growth and food chains.
56. Oceanic pH is not a simple reaction mechanism.
57. Photic zone reactions differ substantially from benthic (no sunlight infiltration) reactions.
58. Oceanic circulation cells are complex and little understood.
59. Surprisingly wind, sunlight (warmth), depth and salinity seem to be the main drivers.
60. Presence of boron, magnesium, sodium, and potassium inhibit pH driven reactions.
61. Benthic reactions are driven by pressure, temperature, and sulfate levels in the water column at depth and bottom sediments.
62. Availability of organically bound Ca, Mg, P, K may also represent either inhibitors or limit their availability.

63. Research has been largely limited to empirical observations on a sporadic basis with supporting laboratory analysis still being in its infancy.
64. Accordingly, data, while somewhat available, stays largely regionally focused.
65. While some research alludes to possible solutions for this major climate change issue, none definitively state a direction for proper definition, methods, or solutions.
66. PEI modified (polyetherimide) sodium bentonite could be a CO2 absorption candidate but that does not address permanent fixation which is much more desirable.
67. Benthic bottom sediments are biogenic reducing environments that would release absorbed CO2 from the bentonite, so not a good idea.
68. It is possible that a photic zone ca / mg / b carbonate in all its polymorphs can be precipitated by addition of a nucleating particulate such as CaCO3, CaO, Ca (OH)2 or MgO or Mg (OH)3.
69. Others are also possible but not explored at this point such as <10-micron CNT' etc.
70. Archaea (a microbe) could also be used to reduce biogenic CO2 and could then function as nucleators much as coral does.
71. Also, iron salts (NOT ferric chloride) could be used as flocculators (there is such a term) that would agglomerate and precipitate a stable but complex chemically stable compound that would resist benthic sediment reduction as well.
72. A key insight by this author would use airplane (not ship) delivered ultrafine (<100 micron) CaO and CaCO3 as nucleators; because they are proven at smaller scale but also are widely available and inexpensive (insight).

73. Air application would be via application along mid ocean ridges allowing rapid mixing, reaction, and precipitation via benthic circulation cells.
74. Photic downwelling zones would also be prime candidates (insight).
75. Since benthic upwelling locations show the highest CO2 levels, this makes sense.
76. Initially CaO should be applied to modestly raise the oceans' pH which does dramatically effect CO2 dissolution and its then precipitation as an insoluble calcium carbonate (insight).
77. Secondly, then CaCO3 may be applied to provide a nucleation agent of calcium carbonate which would additionally bind remaining dissolved CO2 as an insoluble calcium carbonate or its similar insoluble polymorphs (insight).
78. Some research implies up to 80% reduction in non-biogenic CO2 levels with application being light but steady over a period of some months (or years) in the range of 0.1 - 0.2 mg/l / m2 / months would likely accomplish what is needed without adverse biota impact.
79. High altitude application from tote bags discharging from freight planes such as C-130's would be ideal as an application method (insight).
80. Other more elegant methods likely will be found but none less expensive and none more doable with today's technology.
81. A light "rain" of CaCO3, its polymorphs etc already happens in the benthic water column.
82. An increase in that "rain" accumulating to some small number of inches for some years will cause no issues at all I suspect, and the dissolved oceanic CO2 problem is in the past where it belongs.

PLANETARY ENGINEERING SCALED SOLAR ALBEDO CONTROL

Publication date: April 20, 2021

Synopsis

I explored this topic at roughly the same time as I looked at oceanic CO2 removal as a point of reference. A thorough look at solar albedo problems and their mitigation revealed a few general insights that I thought could be useful with immediate telling effect. None of those insights involved any type of new technology or anything approaching a commercial opportunity.

This climate change caused effect should be easily mitigated against with control somewhat possible. Funding would be readily available for the necessary research and scale-up programs necessary to largely eliminate any knock-on issues.

I do think this chapter is worth a read and further debate.

Introduction

As a first step toward atmospheric carbon removal the world community needs to look at deploying simple, low-cost methods for solar albedo control on a targeted basis. That mitigation solution is a “treat the symptom” approach. I am proposing that we attempt to “treat a symptom of the disease” to slow down or prevent further Arctic / Antarctic ice loss and permafrost melting. That can be done as a first step run up to the second more important solution. It will teach us to think and work at planetary scales and how to anticipate unintended problems in what

is otherwise very complex and largely unknown systems. It will be the hardest problem our society has ever attempted to solve.

Concept

I propose that we apply a fine aerosol (very small droplets) of seawater into our atmosphere on a near continuous basis just upwind of areas we wish to reduce albedo within. Such as adjacent to the Arctic / Antarctic margins, upwind of Greenland, upwind of major desert areas such as the Sahara, Kalahari, and Gobi deserts. Their combined effects will likely reduce our global warming to within manageable limits. Certainly, within limits that will allow the development and deployment of DAC planetary scaled installations on a worldwide basis that would solve the whole problem. That rollout would take decades of time. Solar albedo control would take only a few years.

A simple summary by others may say this better is below.

A link to the cited article: Wind-dependence of sea-salt and non-sea-salt aerosols over the oceanic environment

“Modification of cloud albedo by controlled emission of sea spray particles into the atmosphere has been suggested as a possible geoengineering option to slow global warming. Previous global studies have imposed changes in cloud drop concentration in low level clouds to explore the radiative and climatic effects. Here, we use a global aerosol transport model to quantify how an imposed flux of sea spray particles affects the natural aerosol processes, the particle size distribution, and concentrations of cloud drops.

We assume that the proposed fleet of vessels (airplanes at altitude not ships) emits sea spray particles with a wind speed-dependent flux into four regions of persistent stratocumulus cloud off the western coasts of continents. The model

results show that fractional changes in cloud drop number concentration (CDNC) vary substantially between the four regions because of differences in wind speed (which affects the spray efficiency of the vessels), transport and particle deposition rates, and because of variations in aerosols from natural and anthropogenic sources.

Using spray emission rates comparable to those implied by previous studies we find that the predicted CDNC changes are very small (maximum 20%) and in one of the four regions even negative. The weak or negative effect is because the added particles suppress the in-cloud supersaturation and prevent existing aerosol particles from forming cloud drops.

A scenario with five times higher emissions (considerably higher than previously assumed) increases CDNC on average by 45–163%, but median concentrations are still below the 375 cm−3 assumed in previous studies. An inadvertent effect of the spray emissions is that sulphur dioxide concentrations are suppressed by 1–2% in the seeded regions and sulphuric acid vapour by 64–68% due to chemical reactions on the additional salt particles. The impact of this suppression on existing aerosol is negligible in the model but should be investigated further in the real environment so that inadvertent impacts can be excluded."

Finally, seawater is essentially free and in unlimited supply. All we need to do is deliver it somewhat accurately with sufficient quantity and frequency to make the affect we want in a predictable manner. Mistakes would be inevitable. Recovery from those mistakes would be nearly immediate.

Notes

- Climate change is beginning, and we are past the tipping point.
- Atmospheric carbon removal is crucial to slow or stop climate change.

- Industrial scale solutions cannot be scaled sufficiently to affect its major driver - atmospheric carbon accumulation and all its derivative issues.
- Terraforming aka planetary engineering or geoengineering is the most likely engineering concept that grasps what must be done at full scale.
- Science fiction must become science fact with no chance of "do overs".
- Mission Impossible must be mission fact.
- No new science or physics, no new chemistry, no “unobtainium” allowed - we have no time.
- O3 and CH4 are both negatively affected by increasing temp and concentration.
- O3 level increases from NOx sources mostly.
- O3 decreases plant’s ability to uptake CO2.
- CH4 levels are controlled by time and offgassing sources such as the arctic thawing.
- Feedback loops abound and many are not well understood.
- Low altitude O3 levels are increasing and are very harmful to life.
- CH4 is aggressively reduced by OH- (hydroxyl) levels which are largely controlled by O3 level.
- Best method for rapid CO2 and CH4 mitigation is DACC.
- Most rapid single reduction for CH4 would be leak detection and elimination in gas transfer pipelines.
- Second would be to mitigate offgassing from arctic permafrost.
- Increasing albedo by cloud growth over marine areas makes most sense now.

- Seawater spraying by at altitude aerosol ejection makes sense from a nucleation perspective.
- Beware of reaction chemistry with SO2 aerosol ejection (as proposed by others) at altitude which could initiate acid rain.
- Microsphere ground coverage with SiO2 might work in Arctic / Antarctic areas but deployment and renewal or reapplication are a real problem that might well be insurmountable.
- Solar shading is likewise impractical to pursue.
- A global strategy must be used on local / regional temperature affected areas will be a practical problem.
- Modelling using real-time global circulation data is key for any kind of effective feedback loop control.
- Real time all altitude wind speed, humidity, temperature data on a global basis does not exist.
- Albedo detection and control from microsat remote sensing might be ideal for several reasons.
- I advocate that a combination of DAC from many (1000 or so) at scale installations plus seawater spraying in select locales will work best for initial best effect.
- Location / locale for seawater spraying might be Arctic / Antarctic littorals and desert margins.
- Maybe Sahara, Kalahari and Gobi deserts should be seawater spray treated to mitigate albedo issues due to regionally associated radiative forcing.
- DO NOT use freshwater unless it has high calcium or iron for nucleation purposes at altitude.

- Altitude for seawater spraying is largely unknown at this time but initial modeling stipulates a range of 35k - 50k feet might be "best" as a start point.
- Start at a modest scale to help define and then design site and application plans.
- A start ASAP would be ideal.
- Do not wait for remote sensing data to accumulate, there is practically speaking no time left.

CY2050 HOUSING MATERIALS

Publication date: April 1, 2021

Synopsis

I think that all people deserve single family housing from a philosophical perspective. Please do keep in mind that I am apolitical and still somewhat religious albeit in no organized way which may explain the first sentence.

Accordingly, and to accomplish that goal sources, means and methods for constructing desirable housing need to be found. After a serious effort at evaluating current housing construction methods and materials I arrived at the following conclusions.

Cellulose is universally available anywhere humans live for any appreciable time. Making cellulosic foams that are rigid enough and durable enough to work well both structurally and from an insulation perspective is becoming known although not widely yet. A modest effort would make that knowledge widely known and available. I consider that very desirable especially in the coming decades.

Similarly thin gauge roll formed steel ribs over varying geometry for the house frame and wiring runs are also widely available. Concrete is widely available, but the required wiring is not now available. Said wiring could be made available within 5 calendar years on a global basis with a modest effort. No real insights of unique value were made just a simple synthesis of thought by others and me.

Introduction

This summary topic report update concerns the need for supply of single-family homes in an increasingly resource challenged world such as will be the case in calendar year (CY) CY2050 and beyond.

Interestingly, bits, pieces, and parts of that supply exist now. Some examples of these bits, pieces and parts would be using supercapacitors for off peak energy supply in a variety of existing application and the increasing use of ground or geothermal heating and cooling systems. Both examples are benefiting from increased use making them more robust and safer and much less costly.

The missing ingredient to pull the product together that must be defined and proven is how to efficiently integrate those bits, pieces, and parts into a functional and appealing whole product. That product will need to be visually appealing, much more durable, simpler to assemble and far less costly than current stick-built homes. Further, this author advocates that this product can be used as a “package” globally without negative effect for anyone anywhere.

This author believes this product will be especially appealing by the CY2050 timeframe and beyond because global and national supply chains will be disrupted by climate change. This will leave regional and local component supply and assembly the only reliable sourcing for the needed bits, pieces, and parts.

Currently, builders always have several “pairs of hands” touching the bits, pieces, and parts with their attendant stacked margins. Those hands inevitably delay

delivery and add cost and use of resources that needn't be spent. By CY2050 those delays and their need for additional specialized resources will be cost and time prohibitive and may also cause real societal harm by attempting to use resources that can't be replaced or reused. Not least, the finished supply of aluminum and copper by CY2050 will be problematic. Urban mining and recovery of those metals will still be in its infancy. Therefore, effective work arounds need to be found and proven asap. Thankfully solutions do exist.

This author wants to provide a simple descriptive framework for methods and materials that will be available locally and at worst regionally. Ease of construction for least cost with extreme durability and with no associated loss in standard of living is my goal. I think my notes will outline this framework far better than a lengthy written description ever could.

First, an introduction of infrastructure as a topic and what it does and why housing is a key component within it seems useful. Infrastructure such as roads, bridges, power grids, housing and internet access is now required for any society to be successful.

Further, we are citizens of the most globally advanced society with no qualification. Maintaining that superiority requires that we find new ways to fund and force infrastructure development through time with both little input and monies from government. The need for infrastructure does not change but its needs do change. How to keep infrastructure both functional and relevant through time offers some real challenges that must be addressed, or societal

failure will result. Oddly, single family housing as an integral part of infrastructure is often overlooked or simply forgotten. Why its forgotten could easily be its own paper.

A pertinent quote worth mentioning:

> "Strength lies not in defense but in attack. Attack the problem"

Infrastructure can also be described as the backbone of society. Without continuous infrastructure development and support society either cannot exist, or it begins to fail if it had it and it fails without repair sufficient to keep it working. Societal failure can be difficult to recover from, if that is even possible, if history teaches us anything. Infrastructure therefore requires funding and ongoing support that cannot be stopped. How we can do that as it pertains to single family housing is the subject of this simple and short paper.

Concept

Single family housing is ubiquitous throughout human society. It takes many forms depending on locale, cultural norms, climate demands and available materials. Commonalities do exist. They have walls, roofs, doors, windows and usually some method to heat them. In some societies cooling them is wanted and needed.

Increasingly in-home power distribution is becoming a requirement. Internet access may also be wanted or needed.

Answering all these requirements, wants and needs will, by CY2050, become a universal demand. Materials and methods to use them will be available by CY2050 to answer them all. No one design will exist, but a plethora of designs will be available or developed locally on an ad hoc basis. None will be too boring or too drab. Pride of place is a thing I believe. They will be energy efficient, durable, adaptable, and safe.

This author knows that his modest attempt at a look forward will change based on discovery and development through time. That is as it should be. His following notes section should answer most of the questions people will have and will pose many more.

Homes in CY2050 and beyond will need materials that can be sourced regionally. National and global supply of commodities will be difficult at best. Specialty supply of luxury components may be nearly impossible globally due to resource and energy constraints. That situation is not a bad thing, it will force innovation and creativity to answer that want.

Various forms of specialized cellulosic foams and materials will likely comprise the walls, roof, and flooring of homes. Cellulose can be sourced from many types of vegetation including trees and waste packaging. Foaming materials are normally organic and can be sourced at worst regionally.

No use of mined hydrocarbons would be needed.

Said foams would be supported within a framework of roll formed steel struts to create stable and durable walls and roof. It would be pest proof with no following hazards. Exterior wall coatings would be largely spray applied carbon captured and colored concrete. Most houses would rest on a poured carbon captured concrete foundation with carbon fiber or compressed cellulosic “FRP” rebar. Wiring would be a copper / graphene alloy with very high conductivity and low resistivity. Wall imbedded graphene supercapacitors supplied with power from the local micro or smart grid would directly supply house power demands. All housing devices and appliances would use DC power for efficiency that eliminate inverter losses.

Notes

- Housing by CY2050 will have a net zero-carbon lifecycle targeted for their manufacture and operation.
- Sustainability will be the watch word.
- Ground source heating and cooling will be ubiquitous.
- Utilities will be supplied by Smart Grid type sizing with DC throughout the home and possibly output from the local Smart Grid.
- In-situ energy storage will be commonplace.
- Renewable energy power sources will be both local and in-situ.
- Given the Smart Grid concept then expect that common district heating and cooling (DHC) will be commonplace.
- Germany's PassivHaus goal of 15 kwh/m2/y will be exceeded by at least 50%.
- UK's Code for Sustainable homes will be similarly exceeded.

- Global codes will be applied to all by that time.
- USA will largely be supplied by regional grid sources such as renewable energy.
- USA will likely adopt similar goals as the EU and other allies.
- Massless energy storage will be commonplace with structural batteries becoming common.
- Single family homes will still be commonplace.
- Custom designed family homes will still be commonplace.
- Most homes will target zero carbon balance for both construction materials and during use.
- Durability of homes will be on the order of 50+ years with 100+ years becoming the norm.
- Ground coupled water to water heat pumps and air to water heat pumps will be ubiquitous.
- Urban and suburban recovery of copper will be common to cover the expected shortfall of copper by that time.
- Sustainable construction methods and codes will be commonplace by CY2050.
- New construction single family homes will be compliant with those methods and codes.
- Construction materials and methods will be confined to local or at most regional supply.
- Copper (or aluminum) wiring will be difficult to reliably source by CY2050.
- Graphene alloyed copper wiring will be capable of regional manufacture and supply by CY2050.
- Graphene alloyed copper wiring will be at least 20% more conductive than conventional over gauge copper wiring.

- Graphene based supercapacitor energy storage devices will be common and sourced regionally by that time.
- Graphene supercapacitors will not require heat management.
- Graphene supercapacitors can be imbedded in the housing structure itself.
- Said supercapacitors will be the main source of power for the structure.
- Organic coating cladding of all wire should be self-healing.
- Said structure and all devices within it shall be DC powered.
- Distributed heat and cooling (DHC) sources shall be ground or geothermally sourced locally.
- DHC sources will be capable of supplying subdivision scale housing using below grade ducting to prevent pest, water, or tree intrusion.
- Local or residential temperature control will remain within limits or ranges.
- Supplemental heating or cooling devices may be used by permit.
- There will be no national electricity grid for security purposes.
- Housing will not use wooden board frame construction for any purposes.
- Housing will use regionally sourced roll formed steel framing of slip fit, bolted, or welded construction as may be required for seismic code compliance.
- Housing will use block formed wall with compressed cellulosic insulation providing at minimum R50 insulation from heat/cold and noise.
- Exterior coating will be spray applied concrete coating with permanent coloring in a spectrum of choices suitable for the locale and climate.
- Interior walls shall have either sheet or spray applied cellulosic coating suitable for the application.
- Flooring shall be highly compressed cellulosic material suitable for the application with an at minimum R30 rating.

- There will be no carpeting of any sort.
- A carbon captured cast in place foundation of concrete construction with support piers as needed will be used in all locales and will have an R60 rating.
- An alternative foundation and wall coating could be a color blended and compressed cellulose stabilized and cast with an ambient temperature cure epoxy resin matrix to replace concrete completely.
- Roofing shall be spray applied or sheet compressed cellulosic foam with underlying cellulosic foam insulation capable of supporting RE sources.
- Roofing shall also be compliant with snow and wind loads and stresses dependent on the locale with a minimum of R45 insulation value or more and preferably R90.
- Trusses shall be roll formed steel of appropriate shape to handle any anticipated static and dynamic (wind) loads.
- Windows shall be triple pane optically transparent but capable of photoreactive shading and will provide a minimum of R30 insulation value.
- Doors shall be "sliding" in all instances and must provide an R45 insulation value when closed.
- Code compliance will be required in all instances.
- No national or internationally supplied materials should be used in construction, nor should it be necessary.

THE NEED FOR REGENERATIVE AGRICULTURE

Publication date: Monday, May 10, 2021

Synopsis

This chapter' topic is already gaining traction as a trending topic on social media. When I wrote it was not. Since I never published except in the cloud it wasn't me.

Widespread drought or drenching rain and floods are becoming a new norm in much of the world's agricultural areas. Also, and as importantly, manufactured fertilizer is becoming difficult and costly to procure due to war mostly. When taken in context I saw a need to investigate agriculture practices, methods and means to look for a next step. One that didn't need fertilizer and one that could be easily adapted to climate change impacted areas. I found it and assembled the rest from a variety of sources.

In this instance heavily vested interests, whether local, regional, or national will work diligently to impede the progress of adoption. Why that would be a fact should be self-evident by the end of this chapter.

I deliberately did not identify unique insights of mine. Although they are included. Reading this chapter will help people appreciate what regenerative agriculture really is and why is will be helpful when climate change really takes hold. It will keep people fed when nearly nothing else will do so as sustainably and reliably.

Introduction

Anthropogenic (human caused) climate change effects on air / water / soil ideally would need a single point approach to mitigate or solve those effects. The sheer scale of the problem called climate change prevents that single point approach. It is a planetary scale problem not a point source problem very unfortunately. Therefore, and logically, we must take on all three at once to adapt to and overcome climate change effects before they overwhelm us. We can, at least, mitigate those effects to sustain our society.

More importantly, this is a global problem that will require global solutions to resolve those effects. That may or may not happen for a variety of obvious reasons. I suspect that it may not happen. But I'm not paid to be optimistic.

The timeframe for these effects to take hold and cause not only global warming but also widely variable rainfall / wind events is roughly starting now and lasting for the indefinite future with a new stable climate future largely unpredictable but on the order of centuries from now. We have all seen this happening. Many of us deny it.

Soil produces most crops. They are hugely variable in composition and are globally dispersed. Soil science is largely in its infancy though for a variety of sad reasons. Regardless of knowledge, agriculture depends on a stable soil platform to produce predictable crop yields. That dependence is largely based upon locally derived knowledge that is at best empirical.

Regenerative agriculture addresses these issues in simple ways and quite effectively. A description of this relatively new approach to agriculture follows by others.

A link and title regarding the excerpt below: Regenerative agriculture: Merging farming and natural resource conservation profitably

[1] "Most cropland in the United States is characterized by large monocultures, whose productivity is maintained through a strong reliance on costly tillage, external fertilizers, and pesticides (Schipanski et al., 2016).

Despite this, some innovative farmers have developed a regenerative model of farm production that promotes soil health and biodiversity, while producing nutrient-dense farm products profitably. Little work has focused on the relative costs and benefits of novel regenerative farming operations, which necessitates studying in situ, farmer-defined best management practices. Here, we evaluate the relative effects of regenerative and conventional corn production systems on pest management services, soil conservation, and farmer profitability and productivity throughout the Northern Plains of the United States.

Regenerative farming systems provide greater ecosystem services and profitability for farmers than an input intensive model of corn production. **Pests were 10-fold more abundant in insecticide treated corn fields than on insecticide-free regenerative farms**, indicating that farmers who proactively design pest-resilient food systems outperform farmers that react to pests chemically.

Regenerative fields had 29% lower grain production but 78% higher profits over traditional corn production systems. Profit was positively correlated with the particulate organic matter of the soil, not yield. These results provide the basis for dialogue on ecologically based farming systems that could be used to simultaneously produce food while conserving our natural resource base: two factors that are pitted against one another in simplified food production systems. **To attain this requires a systems-level shift on the farm; simply applying**

individual regenerative practices within the current production model will not likely produce the documented results."

Finally, I began assembling this summary topic' reference library with some trepidation based upon my own experiences with this so called "market" or segment. Fortunately, my persistence has led to some reasonable observations and what may be a next steps path toward developing enough data and predictive knowledge to resolve the largely negative impacts that climate change will cause soils and agriculture and therefore our own food supply.

Background

As nearly always done by this author the background is better said by others with some minor editing and is below.

An excerpt from: Jansson, Janet K., and Kirsten S. Hofmockel. "Soil microbiomes and climate change." *Nature Reviews Microbiology* 18, no. 1 (2020): 35-46.

"During the writing of this review we came to have an even greater appreciation of the value of our living soil and a heightened concern about the future as these fragile resources are being imperiled by the negative consequences of climate change. Soil, which many take for granted and often overlook, is a non-renewable resource and is currently being depleted at a faster rate than it is being formed103. Although, not within the scope of our review, when combined with unsustainable soil management practices, we are on course to lose much of our fertile soils, due to erosion, rising seawater levels, increasingly extreme storm events, desertification, nutrient depletion, and degradation.

The ecosystem services carried out by soil microbiomes are vital towards retaining soil C and provision of nutrients to plants and the importance of soil microbiomes in preserving a healthy soil for future generations cannot be overstated. Although there is great interest in application of soil microbes to mitigate climate change, or to stimulate plant growth under a changing climate, there remain significant challenges for their widespread application. Better soil microbial inoculation and amendment strategies are

needed to optimize the beneficial metabolic routes of natural microbial communities that will lead them towards sequestration of soil C for example.

There is an urgent need to gain a better understanding of the repercussions of climate change to key biogeochemical processes carried out by soil microbes, to use this information to make better predictions of climate impacts and to ultimately design microbial strategies to combat further climate warming and soil degradation.

Although we propose several mechanisms by which soil microbes can be harnessed to help to mitigate climate change, we do not by any means propose that this will be sufficient to counterbalance the loss of soil and generation of greenhouse gasses that is already occurring.

Instead, an integrated approach is urgently needed that would employ best-practices for sustainable soil management to support plant production, store and supply clean water, maintain biodiversity, sequester carbon, and increase resilience in a changing climate.

To achieve this goal, we must connect the fine-scale detail arising from microbiome studies to the landscape scale resolution of ecosystem services and most climate models.

Therefore, another priority is to incorporate knowledge about soil microbial metabolic pathways and interactions into predictive models of the impacts of climate change on important ecosystem services carried out by the soil microbiome. And most importantly, we need the political will and a global dedicated effort to curb the emissions of greenhouse gases that are the root of climate change.

Soil organic carbon turnover

Plant and animal detritus are decomposed by soil microorganisms and fauna. Some of the resulting small molecules are assimilated into microbial biomass and used for respiration, enzyme production, metabolites, or reproduction. Collectively these molecules contribute to the active pool of SOC, along with rhizodeposition and other metabolites that fuel microbial populations.

As microbes die and turn over, some of these molecules stay in the active pool, recycling for months to years, while other components are part of a passive SOC pool that can take thousands of years to turn over104.The passive pool is comprised of decomposition products that are no longer favorable for microbial metabolism under the current environmental state due to the physical and chemical availability67. During SOC decomposition a key environmental factor that determines the flux of greenhouse gases

to the atmosphere is the soil hydrology. **In wetter, anaerobic soils, organic carbon can be metabolized to CH4 which is 34 times more potent a greenhouse gas than CO2.**

The residence time of the active SOC pool is dependent on the C use efficiency (CUE) of the soil microorganisms. CUE determines whether the C is respired, producing CO2 in the process, used to produce enzymes to acquire resources, produce metabolites for chemical signaling and growth regulation, or to build biomass. Abiotic conditions (temperature, substrate availability, redox conditions) influence both cell physiology and CUE. Together, the CUE of populations of species creates a community response. At the community scale, greater CUE occurs with efficient biomass production (more biomass production per unit C assimilated). Research suggests that some microbial communities have a higher capacity to store soil C than others. For example, a higher ratio of soil fungi: bacteria can lead to higher amounts of soil C storage, due to retaining of C in fungal biomass compared to C loss by respiration of CO2, i.e., a higher CUE. This metric is, however, controversial because fungi also have capacity for decomposing complex organic C pools with oxidative enzymes, which may lead to greater decomposition, contributing to the active SOC pool. Predicting how CUE as an organismal trait is expressed at the community scale remains a challenge, because it is difficult to constrain variability in CUE due to interspecies interactions and environmental conditions.

Microbial CUE at the ecosystem scale integrates interspecies interactions and community turnover105,106, reflecting biomass production and decay relative to soil microbial respiration. **Developing a mathematical understanding of what drives ecosystem CUE and the feedbacks with climate forcing is a pressing challenge to advancing C sequestration through microbial activities.** Recent predictive models of the impacts of climate change on the soil C flux, i.e., the Community Land Model, have included a module for soil biogeochemistry107 that accounts for the influence of CUE and the ability of soil microbes to adapt to a changing climate as key parameters. These models still require further cross validation with experimental data, but they could lead to improved predictions of the impacts of climate change on C flux and other biogeochemical processes carried out by soil microbes."

Another telling publication by others is below.

An excerpt from: Amundson, Ronald, and Léopold Biardeau. "Opinion: Soil carbon sequestration is an elusive climate mitigation tool." *Proceedings of the National Academy of Sciences of the United States of America* vol. 115,46 (2018): 11652-11656. doi:10.1073/pnas.1815901115

“Mitigation Versus Adaptation

We fully agree with soil carbon sequestration advocates that any carbon sequestered is a good thing, and soils can indeed regain some carbon. However, the promotion of this method to significantly alleviate our carbon dioxide imbalance is somewhat irresponsible and has political implications. The suggestion that soil carbon sequestration may be a “bridge” serves only as a reason to yet further delay action (27). Pursuing soil carbon as a climate-mitigation strategy could have an impact on scientific credibility. By not fully considering the barriers that inhibit implementation, some in the soil science community may be committing to an unachievable goal. More than a decade ago, Smith et al. (28) clearly stated this:

An excerpt below from: Nolan, Connor J., Christopher B. Field, and Katharine J. Mach. "Constraints and enablers for increasing carbon storage in the terrestrial biosphere." *Nature Reviews Earth & Environment* 2, no. 6 (2021): 436-446.

“Given the recognized biological, economic, social, political and institutional constraints on the implementation of soil carbon sequestration measures, the scale of carbon sequestration in agriculture will rely more upon overcoming these constraints than upon filling in gaps in our scientific and technical knowledge.”

They noted there is a large gap between the maximum physical potential and that achievable in a complex society (Fig. 2). The present status of soil carbon sequestration a decade later seems unchanged, given a lack of significant progress in the related social science issues and the ever-changing political climate in the nation.

Although soils and its agriculture are seemingly unlikely to help us remediate climate change, they are almost essential for us to survive it. In the soil–climate research arena, the current emphasis on carbon sequestration as the primary goal—with ancillary improvements in water management, soil erosion, and food security—seems almost inverted in its prioritization. Better soil carbon management is best placed within a framework of a multifaceted approach and its effort to further improve farming methods in this century.

This author also recognizes that inorganic fertilizers and pesticides will not be widely available when climate change and its infrastructure impacts take hold. I suspect this will begin to occur by CY2030 and become rapidly worse thereafter.

Another perspective also is pertinent now and should be addressed immediately which is just below.

An excerpt from: Tam, Kristen, and Olivia Bielskis. "Stimulating Antitrust Enforcement to Expand the Regenerative Agriculture Movement." (2021).

[3]"Competition in the agricultural marketplace has significantly declined because of decreasing antitrust enforcement and increasing consolidation. In the current market, the largest firms control disproportionate percentages of market power, threatening consumer prices, principles of equal economic opportunity, and viability of small farms and ranches. Contrary to the notions promulgated by Robert Bork's "consumer welfare standard," which claims that the federal government should regulate mergers sparingly for the supposed benefit of the consumer, consumer prices have increased due to this perspective being applied to jurisprudence and enforcement. Market consolidation also harms principles of fairness and objectivity in policy. Seeing as large firms often contribute such a substantial percentage of a given agricultural product's output, if the firm is significantly compromised financially, they must be "bailed out" because the market inherently relies on their output and constructed dominance. When large firms or farms have such robust security, they are less likely to innovate, improve the quality of their products, and invest in more sustainable agriculture practices.

The Intergovernmental Panel on Climate Change (IPCC) prescribes that the world needs to limit global temperature rise to 1.5 degrees Celsius by 2050, which is contingent upon decreasing greenhouse gas emissions. Agriculture contributes to 10.5 percent of the United States' emissions, and the ability to reduce emissions is hindered by large farms' tendency to employ practices that increase emissions, while small farms, which are being driven out by corporate merges, are more likely to employ sustainable farming practices such no-till, compost as fertilizer, and planting cover crops. Agriculture consolidation has largely increased due to non-precautionary approaches by the Supreme Court and federal regulation agencies, the Federal Trade Commission and Department of Justice. Specifically, the Supreme Court's ruling that the "threat of loss of profits due to possible price competition" does not constitute antitrust harm has hindered the implementation of the Clayton Antitrust Act. Additionally, the federal agencies responsible for regulating mergers have increased the number of mergers they approve, allowing consolidation of the marketplace to continue. The lack of strict antitrust regulation to prevent mergers from holding hostage undue percentages of

the marketplace is hindering the growth of regenerative farming, a set of practices that will be integral in meeting the IPCC climate change goals."

The above quote is probably most telling and outlines succinctly where opposition to this change will originate. Forewarned is forearmed.

My summary notes section follows. I attempt to capture my research insights in a list of notes. Hopefully it is helpful.

Notes

- Climate change (CC) effects on soil by increasing temperatures or drought can have dramatic effects especially at lower latitudes.
- CC can have a negative effect on carbon allocation to soil microbial biomass.
- Carbon sequestration might be a big problem with > 60% reduction in carbon fixation readily observable in early CC observations.
- CC can affect ag crop yields as much as >60% lower which directly impacts global food security = a big problem.
- Regenerative Agriculture advocates local solutions to maintaining an efficient biomass in the soil which equals sustaining food production during CC.
- CC will affect soil organic matter % content (biomass) that expresses itself as lower soil water content and increased erosion.
- Regenerative Agriculture will eliminate "plow pan" altogether which expresses as much enhanced soil moisture content and sustained yields.
- CC will force biomass to adapt to changing conditions which will be expressed as lower crop yields etc in the short/moderate term.

- Soil fauna or organisms will be negatively affected and that will affect erosion (wind and water) plus also the C/N cycles.
- USDA publications are sparse on this topic especially over the last several years.
- Water pipelines (not canals) from water rich to water poor / irrigated areas might be needed to sustain crop yields.
- Artificial fertilizers will be needed during early phase of regenerative agriculture but not thereafter.
- Regenerative Agriculture yield range from 0.8 – 1.1 over conventional agriculture which is the baseline roughly 75% of the time.
- All in costs are 10% lower with regenerative agriculture versus conventional agriculture 100% of the time.
- There is a serious lack of soil chemistry / biology modelling and its effects on soil C, fixation, and nitrogen interplay.
- Aggressive soil supplementation such as biomass and nutrients might be needed to sustain yield in CC conditions.
- Main stresses for P, Ca, Al/Mn (toxicity) plus also N are still poorly understood and badly modeled for CC' affects.
- Biomass does not represent enzymatic activity.
- Work to understand how atmospheric nitrogen will impact both agriculture and forestry for which little modeling has been done.
- Mention food security as a principal CC concern for which soil chemistry and its' adaptation to CC is little understood.
- Water demand will overall increase in any CC scenario and location due to climate variability.

- CC will force regional and local adaptation of crop type and animal husbandry much of the time versus traditional agriculture “monoculture” approach.
- Sustaining ag crop yields will demand a 16 - 50% more irrigation volume for any location or climate but especially at low latitudes.
- All countries will be negatively affected by regional CC affects including induced competitiveness for resources of any sort.
- CC combined with trade liberalization show that global food production, welfare and GDP fall over time while food prices increase.
- CC will likely have regional extreme effects with global effects somewhat moderated and muted, forcing mass migrations.
- Developing countries are low latitudes usually and will suffer worst impacts of CC.
- Complacency continues to be a problem because society doesn't plan well for futures effects.
- Cost / benefit analyses on work in a stable and predictable economic and climate environment but not in a CC scenario.
- Broad stroke analysis of GDP / yield / temperature does not illustrate major regional impacts of ag / soil / food impact good or bad.
- Well-watered areas will do well to plant rotating or perennial crops vs trees because global impacts will be broad, and trees don't work.
- Irrigation + gaseous O2 feed = 10%+ crop yield.
- Irrigation + chemical (catalyzed aspartyl or aspartic acid) will also give 10%+ crop yield.
- Some form of irrigation water augmentation using both supplements above will help sustain crop yield in CC impacted ag areas.

- Remember that little work has been done on soil fauna and CC or anthropogenic impacts on them, but it is known that they control soil biomass to a large degree.

NEXT GENERATION HIGH SPEED RAILWAYS

Publication date: Monday, October 19, 2020

Synopsis

This is a derivative topic that I explored just after investigating what a hyperloop was intended to be and what it would likely need to become to function safely. Realizing that the hyperloop concept would likely not become a reality anytime soon I began to look at its close corollary railroads, their engines, and carriages (yes that is still a word in use).

Being a practical person, I intuitively knew that whatever I did would have to work on existing railroad infrastructure (rails, bed, bridges) with few, if any, changes.

I discovered that it was not only possible to adapt what existed but take it in a new and much more sustainable or lower cost and expense direction thereby eliminating the need for hydrocarbon fuels. That was compelling I believed and still do so. Additionally, the new design concept would allow high speed operation with no difficulty and operation in all climates, elevations, and latitudes with no infrastructure modification except a very minor bridge modification for the increased speeds.

High speed for me is 80+ miles per hour with occasional bursts where appropriate to 100+. Not high by other countries standards but certainly high enough for North America with most importantly no following risk. Just faster, cheaper, and more durable. Many unique insights were discovered as well.

Introduction

The early adoption and then more widespread use of energy sources that both save money and increase profitability is not a new idea for entrepreneurs, scientists and governments and is a goal they aspire to achieve. Everyone wants to innovate or create the latest big thing that pushes society forward toward a yet brighter future hopefully for a large profit.

I take that paradigm and push it yet another step forward. I espouse the adoption of stepchange technologies that can offer least cost operation for least risk without the need for hydrocarbon energy sources. This simple strategy certainly can apply in the rail transportation market just as it would apply to most markets. The technology changeover will offer a large profit opportunity for all stakeholders.

In this instance this strategy encompasses using a highly efficient non-hydrocarbon energy source and other closely integrated designs that already exist but above all else, those that are simple and cost efficient to deploy. It may not offer large profits for existing stakeholders, but most would endorse a least cost, least risk approach. Some may attempt a catch and kill approach regardless because change is a risk.

Answering “why” do it might be vital this point. Why – because we are in the grip of a global pandemic that has changed and largely disrupted our global economy in a staggeringly short period of time. Finding the way to recover our economy and its various supply chains while also conquering the pandemic becomes a first

order priority. This global strategy could well use this author's modest work as outlined herein to positive effect as a portion of that strategy.

A sizeable resource and research publication library has been assembled and should be used accordingly if interest proves favorable.

Railroads have proven to be cost and time efficient in the delivery of goods within a country's borders and somewhat less so on a continental basis. Making this good (and people) delivery system yet more efficient and timely enough to displace both truck and air delivery requires use of rolling stock of high speed and effiency for least cost. This can be done quickly.

The priority would be replacement of existing locomotive diesel powergen with a new powergen system capable of sustained high-speed transit with little downtime. This powergen would be highly scaleable with modular units likely being developed in the 5 –50 MW-h (or much more) range with high amperage AC available on a 24/7 basis for an integrated unit cost of ~ $300,000 – several million USD (less ancillary hardware that is pre-existing). Said units would be capable of sustained operation in all climactic and topography conditions with industry standard uptime and efficiency or much better. Commercial development monies can likely be provided by USDOE grants. Once decently proven up the private sector could conduct the rollout for a very substantial profit.

Reiterating, the target application for this summary report is least cost power generation (powergen) for onboard railroad locomotive needs that replaces the need for hydrocarbon combustion systems for propulsion and other uses. It does however occasionally require a small volume of startup only dedicated compressed oxygen and hydrogen supplied by conventional means which are or can be made easily and widely available at depots worldwide.

Replacing diesel or other hydrocarbon fueled powergen systems that allows for sustained operation for this application with a simple, easily maintained system has many obvious implications for both market profitability and civilian needs in the event of a sustained logistical supply chain disruption of any kind such as a pandemic or to help mitigate climate change. Affording to do the conversion can be easily done using the energy tax model this author has outlined many times in the recent past.

Concept

This power generation system will create its own fuels from atmospheric gases (hydrogen and oxygen) and then via a proven hydrogen / oxygen expanding gas combustion turbine drive to a coupled power generator that will charge a dedicated bank of sized for the application batteries (think TeslaWall). Said batteries will supply the AC local onboard grid on a demand basis. The system can be designed for 24/7/365-day operation with at least 12 months before first periodic port maintenance.

The forms of “emission” from this power generation system would be excess to need heat as steam.

Avoiding power generation output issues that can vary substantially with both ambient temperature and humidity requires the use of a high alloy intercooled two or three or more compressor stage set of serially piped turbines with supplemental water injection as needed. I do also advocate that these turbine sets be installed in parallel multiples (probably two) to provide scaleable power and necessary backup working from an excess of caution.

An illustration of the basic process also with some notes by others is just below.

An excerpt from: Sanz, Wolfgang, Martin Braun, Herbert Jericha, and Max F. Platzer. "Adapting the Zero-Emission Graz Cycle for Hydrogen Combustion and Investigation of Its Part Load Behaviour." In *Turbo Expo: Power for Land, Sea, and Air*, vol. 49743, p. V003T06A020. American Society of Mechanical Engineers, 2016.

“PROCESS DESCRIPTION OF A GRAZ CYCLE PLANT FOR HYDROGEN COMBUSTION

Figure 1 shows the principle flow scheme of the Graz Cycle plant for hydrogen combustion, and Fig. 2 the associated temperature-entropy (T-s) diagram generated by the software IPSEpro. The plant is based on a proposal by Jericha [9] and consists basically of a high-temperature Brayton cycle and a low-temperature Rankine cycle – a combined cycle. The Brayton part consists of the combustion chamber (CC), the high-temperature turbine (HTT) and the compressors (C1/C2). The Rankine steam loop consists of the heat recovery steam generator (HRSG), high-pressure steam turbine (HPT), low pressure steam turbine (LPT), condenser, condensate pump, deaerator and finally the feed pump supplying high pressure water to the HRSG.

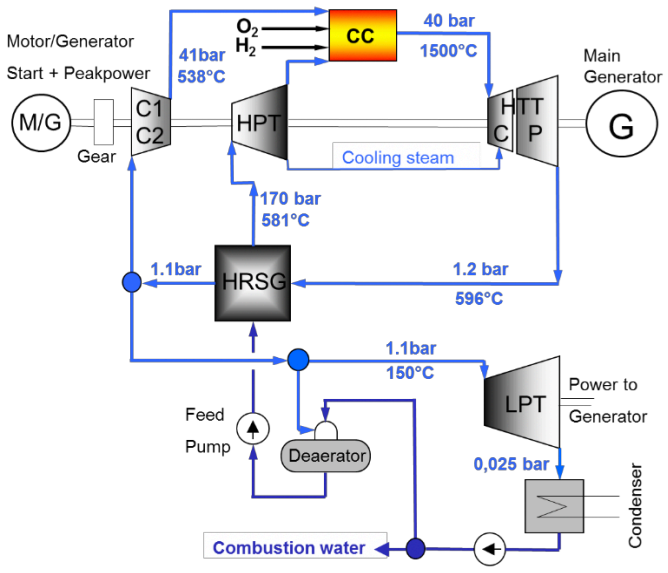


Fig. 1: Principle flow scheme of the Graz Cycle for hydrogen/oxygen combustion"

Maintaining consistent and predictable power generation is key for this process to work. The key is aggressive heat management as shown above.

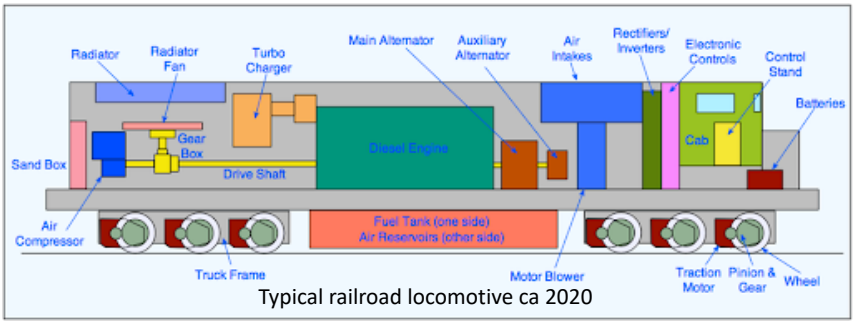
Put another way: "Generally, unlike the heat rate, the net power output from a gas turbine decreases with an increase of the ambient air temperature. This is due to reduced net power output, which is directly proportional to the air mass flow rate; net power produced decreases when the ambient air temperature increases. Practically, a 25% loss of the rated power capacity of the gas turbine at ISO conditions as the ambient temperature reaches 40 °C is reported."

Given that this process issue can be easily overcome by design then this concept then becomes compelling given the application at hand.

In all instances all sub-systems are well proven. No new technology is required.

This author knows that a consistent and appreciable volume of relatively pure H2 / O2 are needed. My concept description for this is just below as both a simple drawing and in text (see below):

NEXTGEN LOCOMOTIVE DESIGN CONCEPT
GOAL MET: No external fuel needs.



Typical railroad locomotive ca 2020

Proposed design changes:
1) Delete turbo charger
2) Delete diesel engine
3) Replace diesel engine with MOF / PSA
4) Delete fuel tank / air reservoir
5) Replace fuel tank / air reservoir with O2/H2 storage tanks

A blower driven raw atmosphere intake contacts a set of three sequentially mounted molecular sieves that would remove [1]water vapor, [2]methane/carbon dioxide and [3]nitrogen from the intake atmosphere volume. The "concentrated" downstream "gas" would be 90%+ oxygen would be compressed in a storage tank and directly used in the combustion process.

Then the molecular sieve separated [2]methane/carbon dioxide would be purged or cleaned from its' molecular sieve using a small volume of the compressed oxygen on a timed basis. The purged volume of methane/carbon dioxide/oxygen would be captured, compressed, and then processed at low pressure (<2bar) and ambient temperature through a photoelectrochemically powered tubular or sheet assembled, optically clear, covered methane "reformer" or "cracker" to make a compressed hydrogen and oxygen product with a small volume of residual of carbon dioxide as

a contaminant. The [1]water vapor molecular sieve would be similarly purged with the excess [3]nitrogen gas on a timed basis with the balance of the nitrogen vented to atmosphere.

Commercially this atmospheric gas separation can be described as a VSA, PSA or VPSA any of which could work. Commercial vendors for the appropriate molecular sieve materials and the gas separation systems exist and should be thoroughly explored and then used as appropriate.

Maintenance needs are expected to be very low and should require nearly or no skilled labor to operate.

Commercially this system will be attractive from both a cost to construct and use (deploy) perspective especially when compared to either conventional or other unconventional (renewable) energy systems.

Alternatively, if the onboard hydrogen supply is too small, compressed methane or natural gas could be used although this would assume that some form of on demand logistic supply was available.

This author has previously specified use of magnetic bearings and transmissions for all applicable systems for similar, although smaller, applications. These are widely available and nicely sized for these applications which would eliminate most of the problems found with rotating machinery and their maintenance.

Again, this author does advocate close integration with other renewable energy generation and storage systems to increase supply optionality in the event of a national and / or regional grid outage of significant duration.

Notes

Goals:

- Goal 1: Nextgen mixed use rail prime mover is the innovation target for this effort.
- Goal 2: Nextgen mixed use rail prime mover must be capable of adoption within 5 years.
- Goal 3: Nextgen mixed use rail prime mover must be least cost, least risk.
- Goal 4: Nextgen mixed use rail prime mover' must be hydrocarbon combustion free.
- Goal 5: Nextgen mixed use rail prime mover must be robust for >1M mile service life.
- Goal 6: Nextgen mixed use rail locomotive must be capable of sustained 80+ mph operation.
- Goal 7: Nextgen mixed use rail locomotive must be operable in all topography's and climates.
- Goal 8: Nextgen mixed use rail trains must be capable of direct use of existing rail systems as is with no modifications.
- Goal 9: Speed of said rail trains shall only be limited by existing rail systems, topography, and weather events.

- All components must be capable of in place maintenance and replacement.
- All components or their associated critical duty items.
- All external power generated shall first charge on board batteries.
- All external power supplied shall be AC for train needs.
- All mission critical replacement components must be local stocked.
- All onboard control systems to be hardened 24VDC.
- All onboard power systems to be AC.
- CO2 sequestration for this application is contraindicated.
- Deployment of said system into full operation shall not be more than five minutes from a dead start with charged batteries (insight).
- Atmospheric emissions shall be low temperature water vapor and trace amounts of NOx and CO2 well below background levels (insight).
- H2/O2 expanding gas turbine power generation must be capable of supplying all on board power needs plus at least 25% of peak demand into the on-board storage battery / ultracapacitor banks.
- H2/O2 heat recovery shall be recycled for pre-heat and methane reformer needs then vented to atmosphere.
- Onboard AC /HVAC needs qualify for integration with a 6 - 10% inversion penalty.
- Methane cracker must be capable of providing at least a 50%+ hydrogen product @ 2 bar pressure (insight).
- Methane cracker can be used as a fuel source:
    - Liquid water (sheet or tube (insight) configured)) using:
        - Liquid water with saturated dissolved methane (insight).

        - Gaseous methane and entrained but not required CO2 within an optically clear shell and tube arrangement (insight).
- Power systems must be capable of sustained stand down or storage - on the order of years with no penalty (insight).
- Power systems must be fully capable of offline no external access (insight).
- Power systems shall be capable of 24/7/90 day operation before significant onboard maintenance.
- Molecular sieve materials must be fines removal pre-sieved then triple bagged with an appropriated desiccant for long-term on-board storage.
- PSA / VPSA or VSA must provide a 90%+ gaseous O2 product @ 2 bar pressure.
- PSA / VPSA or VSA must provide a 90%+ methane / CO2 blended product @ 2 bar pressure.
- PSA / VPSA or VSA must provide a 90%+ nitrogen product suitable for direct emission or other onboard uses such as fire suppression (insight).
- Power systems must be easily integrated and coupled / decoupled with existing onboard drive systems.
- Power system turbines should be two or more output shaft capable to provide flexibility in drive and onboard power system integration and / or repair while at work.
- Said power systems batteries must be capable of providing at least +100% of peak demand for a 2-hour span (insight).
- Power systems must be of unitized construction and capable of 4-hour changeout in depot (insight).

- Said systems must provide enough power for mission critical sub systems.
- Startup external power supply shall be capable of 10-minute deployment support.
- Ultracapacitor components shall be capable of multiple recharges from the battery outputs.
- Ultracapacitor components shall be provided suitable for startup and local or brief operational needs (insight).
- Ultracapacitor output shall be on board DC or AC voltage / amperage selectable (insight).
- Prime mover' shall be hydrogen / oxygen EGT / electric traction motor design.
- Traction motors shall take power from on board high voltage batteries only (insight).
- On board batteries shall be capable of meeting stand-alone operation for not least than 2 hours of sustained operation (insight).
- Sustaining H2/O2 EGT combustion will require on-board compressed gaseous supply (insight).
- Keeping the on-board batteries charged so that the traction motors can demand respond is the EGT' only goal (insight).
- Batteries to be LiON or better and capable of sustained operation.
- Regenerative braking systems including dielectric fluid cooling shall be integrated (insight).
- EGT exhaust heat can be used for environmental control of batteries and indirectly the traction motors on a pass / bypass basis (insight).
- Traction motors must be AC not DC to mitigate resistor heat issues.

- Traction motors shall use a vaporizable dielectric fluid for heating / cooling.
- Radiators for dielectric fluid cooling may be externally mounted on the locomotive or on the following cars by serial connection (insight).
- Heating / cooling of the cars shall be by radiator chilling or EGT heating of the non-hazardous dielectric fluid which may be palm oil or a derivative (insight).
- On-board hydrogen generation shall be by incident solar reforming (previous – by author) serially mounted on the trailing cars roofs and / or the locomotive (insight).
- Alternatively, externally supplied compressed hydrogen shall be provided and supplied from an on-board tank of appropriate design.
- On-board oxygen may be supplied from the incident solar reforming system as a product or more preferentially from a PSA supplied concentrated product (insight).
- Alternatively, hydrogen may be solar reformed from a methane concentrate from a sequentially MOF configured on-board PSA (insight).
- Said PSA (s) may be single but should be parallel installed for redundancy (insight).
- Inlets for the PSA's shall be face mounted into on-board blower assemblies to feed the PSA MOF vessels (insight).
- All on-board process heat exhausts shall be vertical and common in a single stack.
- Existing rail bed shall be used as is with as planned maintenance and replacements as needed (insight).
- External control systems shall be optimized for both on time people and goods delivery at least cost and least risk.

- On board control systems shall include control and use of cooling / heating AC drive motor's dielectric fluid and continuous track monitoring for parallel spacing and displacement (insight).
- Said integrated system shall be capable of 80+ mph operation on average throughout the continental system (insight).
- Existing bridges must be modified to accept increased longitudinal and lateral stresses associated with 80+ mph operation.
- Existing bridges should have both entry and exit friction pads that have proven effective for handling longitudinal stresses.
- Existing bridges should have entry and exit rotational friction devices that have proven effective for handling lateral stresses.
- Existing bridges would then be capable of handling seismic events that are not judged catastrophic.

CY2050 COB Needs

Publication date: June 15, 2021

Synopsis

This topic was explored by me when I began to realize that local truck freight delivery would become problematic in the early 2040's. This would be due to lack of refined hydrocarbons and degradation of our highway system due to age and climate change.

As always, my goal was maintainance of our standard of living while adapting to changing circumstances beyond our control.

Container on Barge (COB) transport is commonplace in Europe where some delay in delivery of finished goods is mitigated by sophisticated planning. That is not the case in anywhere in the America's to any appreciable degree unfortunately.

This chapter outlines how COB can be done in the America's with very little delay in goods delivery. It does require sophisticated and integrated intermodal freight planning.

Introduction

The early adoption and then more widespread use of novel energy sources and nextgen materials that both save money and increase profitability is not a new idea for entrepreneurs, scientists and governments and is a goal they aspire to achieve. Everyone wants to innovate or create the latest big thing that pushes society forward toward a yet brighter future hopefully for a large profit. I take that idea and use it to help solves issues caused by climate change.

This simple strategy certainly can apply in this instance. The idea of a fully integrated freight transport model using air, in-land and blue water, road, and rail plus the need for unique stepchange design concepts to make it all work in a resource constrained world will offer a large profit opportunity for all stakeholders and reciprocal cost savings for consumers or end-users. This paper focuses on the "in-land water" portion of the model. It can also largely resolve the stacked margin problem common in intermodal freight systems today. That simple integration would save the consumer or enduser 15 - 25% of price. The supplier would save at least that much or more as well. A real win/win.

This strategy uses a non-hydrocarbon energy source with other closely integrated existing tech focused only on those that are simple and cost efficient to deploy.

This author has previously outlined nextgen high speed rail, semi-trucks and their roadbed and aircraft designs and use models that accomplish this aggressive goal of making an integrated transmodal freight model happen. It would accomplish significant impact towards achieving our carbon neutral goal by 2050 (maybe as

much as 15%) and offers a practical answer to global climate change and its severe impacts.

A sizeable resource and research publication library has been assembled and should be used accordingly if interest proves favorable.

Containers on Barge (COB) have proven to be cost and time efficient in the delivery of goods within a country's borders and slightly less so on a continental basis. Making this goods or freight (and people) delivery system yet more efficient and timely enough to compete with or at minimum integrate with nextgen truck, rail and air delivery requires use of designs that offer on time delivery for least cost. This can be done quickly. I see this coming to full fruition in an N+5 scenario which is from now + 30 years or ca 2050. A well-financed but domestic visionary can make it all happen.

The envisioned barge design and its freight load will be smaller than is expected or seen now. It will have onboard renewable energy charged LiON battery driven waterjets are the propulsion method of choice. This is not a negative. Barge traffic would be frequent and as far upstream as possible. It would also be tightly scheduled within the integral Transmodal freight model.

These barges would be capable of operation on nearly all navigable waters that would allow their width and length with some basic civil engineering being done and maintained. Average width would be 24 feet and draft would be 4 – 5 feet or

less which opens several thousand miles of navigable water that are otherwise closed to use now.

This powergen could be highly scaleable with modular units likely being developed in the 100 –250 Kw-h range available on a 24/7 basis for an integrated unit cost of ~ $500,000 – several million USD (less ancillary hardware that is pre-existing). Said units would be capable of sustained operation in all climactic and flow conditions with industry standard uptime and efficiency or much better. Commercial development monies can likely be provided by USDOE grants. Once decently proven up the private sector could conduct the rollout for a very substantial profit.

Concept

This author has previously specified use of magnetic bearings and transmissions for all applicable systems for similar design concepts and applications. These are now widely available and nicely sized for these applications which would eliminate most of the problems found with rotating machinery and their maintenance.

Again, this author does advocate close integration with other renewable energy generation and storage systems to increase supply optionality in the event of a national and / or regional grid outage of significant duration.

As is usual for this author, others say it best with some notes by me and is below.

An excerpt from: Platz, Tilman Erich. "The efficient integration of inland shipping into continental intermodal transport chains-measures and decisive factors." PhD diss., Nijmegen: Radboud Universiteit Nijmegen, 2009.

"For the purpose of this discussion, **COB service** is defined as the use of barges to transport containers (hence Container on Barge – author) between water ports as part of the overall movement of a container of freight. The transport of containers by barge would also likely require that a container be moved by at least one other mode of transport for one or more segments of its journey. For example, a container of manufactured goods is transported from the factory to a port on a truck chassis and then transferred onto a barge. The barge carries the container to its destination port, where the container is unloaded and placed onto another trailer chassis and trucked to its destination. If serving a stacked container barge, a port must have the necessary infrastructure to move containers from ship, truck, or rail to the barge and vice versa.

At a minimum, this would require a crane for moving the container onto the barge and probably would require other equipment for moving containers around the port's staging and storage areas. If containers were loaded onto the barge while on a trailer chassis, the equipment demands would be fewer, but the barge's capacity would be less and the cost per container would be higher.

Additionally, ports must have the appropriate berths, channel, and dockside infrastructure to handle barges, tugs, and container-moving equipment.

However, the equipment demands for moving containers by barge are not as great as moving containers by ship, because barge volumes are usually smaller and loading a barge does not create the same height and width issues for cranes.

A **COB network** would be defined, in this discussion, as regularly scheduled COB services that move commodity- or good-filled containers by barge to, from, or between Texas (read "any" – this author) ports with at least some routes having two or more competitive COB carriers. A COB network, in this discussion, also means that COB operators can effectively compete with truck and rail modes.

At present, there are several locations around the world where COB operators are providing service. The most successful of these operations is in northern Europe, particularly in the Netherlands and in Germany along the Rhine River. In Rotterdam trucks now carry less than 50% of the containers to and from the port because of the growing share of containers that are transported by barge. In

Antwerp approximately 1.52 million containers were moved by barge in 2000, and between the ports of Rotterdam and Antwerp, 850,000 20-ft equivalent units (TEUs) were shipped in 2000. In Germany, the Rhine River has become the primary route for containers, and barge operators provide scheduled, frequent service.

COB operations exist in the United States, as well, located along the Columbia and Snake Rivers in Washington and Idaho, along the middle Atlantic Coast, and in Texas. There are also plans to develop COB service in the northeastern United States. Along the Columbia and Snake Rivers, barges carried more than 50,000 containers in 2000 between the port of Portland and the ports of Lewiston, Pasco, Umatilla, and Morrow-Boardman.

Several attempts have been made to develop COB service along the Mississippi River, but none of these attempts has been sustainable. The last COB service to operate along the Mississippi River carried refrigerator compressors that were unloaded from Brazil at the port of New Orleans and shipped upstream to Illinois, where they were then transported to a factory in Indiana. This COB service ended in the mid-1990s (Whirlpool / Evansville – this author).

The development of a container-on-barge (COB) network is a worthwhile proposal because there are several benefits that could be realized from moving containers on barge versus moving them by truck or rail. First, the state's roadways are experiencing increasing levels of congestion that have been exacerbated by placing more trucks on the road to serve a growing population and economy. Although the exact number depends on a barge's size, an average single barge could remove 58 trucks from Texas (any state – this author) roadways. **Second, barges are more fuel efficient than truck or rail. A single gallon of fuel can move a ton of commodities 514 miles by barge, versus moving the same ton 59 miles by truck and 202 miles by rail.** Third, because barges use less fuel than truck or rail, they introduce fewer pollutants into the atmosphere. For example, 10 million fewer tons of carbon dioxide were released into the atmosphere because commodities were transferred by barge instead of by rail (1). Thus, COB service could offer opportunities to lower exhaust emissions in air sheds that do not meet U.S. Environmental Protection Agency criteria for air quality. Fourth, railways have had great difficulty improving their service after the recent takeovers and mergers. COB service would offer shippers another choice for moving freight, and that could increase competition. Finally, COB service could expand the reach of smaller ports with poor landside access by connecting them to areas outside their regions.

Jones Act Restrictions

The Merchant Marine Act of 1920, more commonly known as the Jones Act, prevents foreign-owned shipping companies and foreign built vessels from operating between U.S. ports."

This, then, requires domestic ownership – this author.

Concept

This author advocates the use of a semi-submerged shallow draft hull shape with a bulbous nose and slightly V shaped hull bottom for hydrodynamic efficiency at low speeds. I particularly advocate the use of a RHIB design concept with imbedded articulated thrusters at bow, midships and stern along with dual electric powered waterjet propulsion system. Solar PV and wind turbine(s) shall be used to keep the onboard LiON battery system charged.

A description of a RHIB is just below.

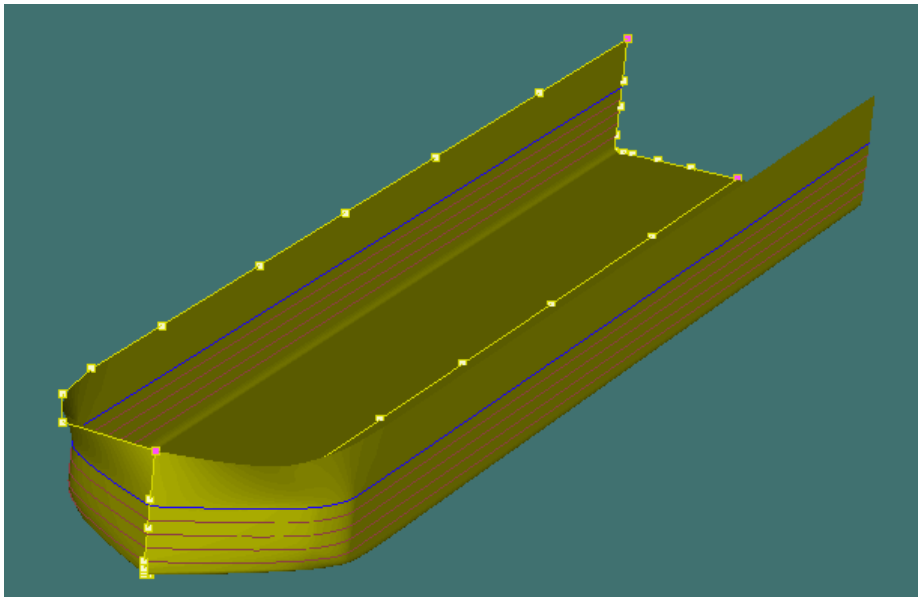
An excerpt from: Litmus International

"A **rigid inflatable boat** (**RIB**), also **rigid-hull inflatable boat** or **rigid-hulled inflatable boat** (**RHIB**), is a lightweight but high-performance and high-capacity unsinkable boat constructed with a rigid hull bottom joined to side-forming air tubes that are inflated with air to a high pressure so as to give the sides resilient rigidity along the boat's topsides. The design is stable, light, fast and seaworthy. The inflated collar acts as a life jacket, ensuring that the vessel retains its buoyancy, even if the boat is taking on water. The RIB is an evolutionary development of the inflatable boat with a rubberized fabric bottom that is stiffened with flat boards within the collar to form the deck or floor of the boat.

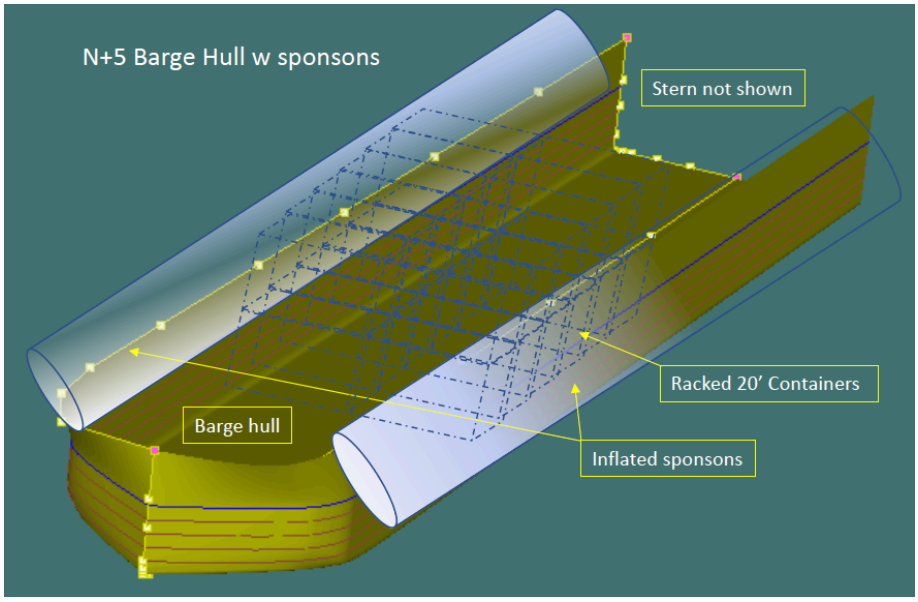
Uses include work boats (supporting shore facilities or larger ships) in trades that operate on the water, military craft, where they are used in patrol roles and to transport troops between vessels or ashore, and lifeboats."

Further, this author advocates the following layout of the barge by shape and container stacking arrangement and thrust systems. The original hull form design source is unknown (I apologize):

Barge Hull Form

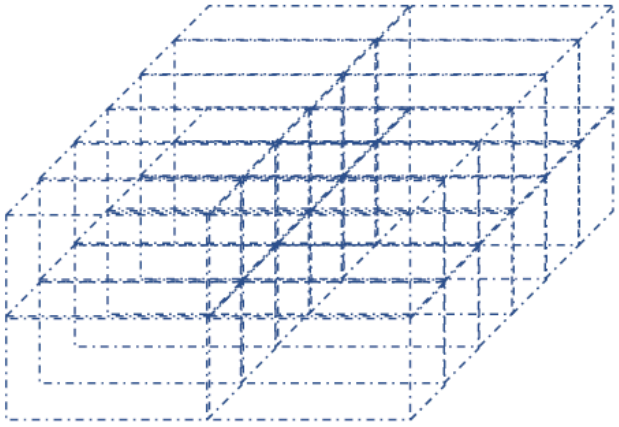


As can be seen above the hull form is semi-submerged with a bulbous bow and flat transom stern. If offer hydrodynamic efficient at relatively low speeds and offer high weight freight capacity with low cost to construct. This author advocates FRP hull fabrication with imbedded basalt or boron fibers for strength.

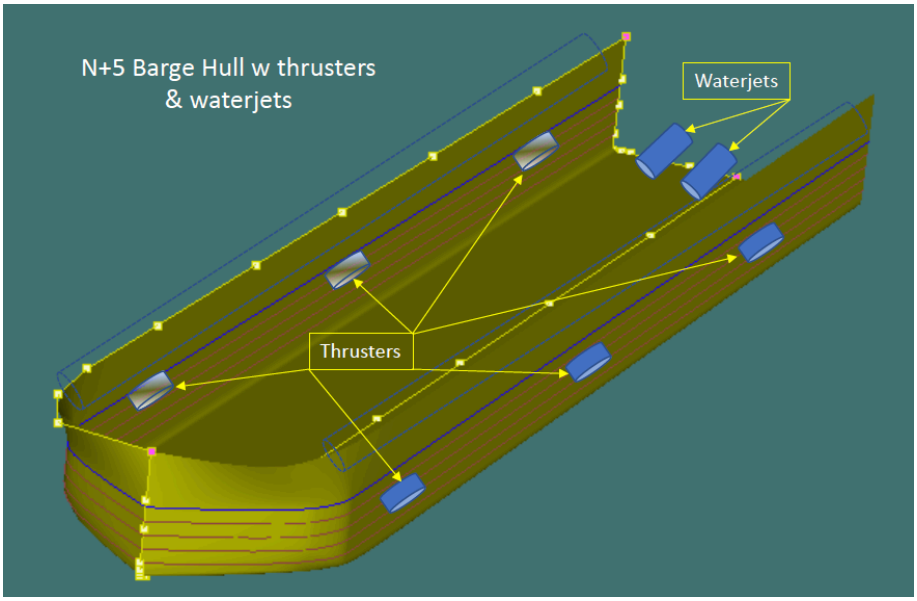


Sponsons are meant to be air inflated or deflated on a near continuous basis over a very long design life measured in decades for low-cost replacement.

Typical 20' Container Rack
w 24 containers



ISO standard 20' containers are this authors' design standard. Transverse beam to beam loading offers operation stability and the ready use of shore-based straddle carriers.



Shallow draft waterjets of a standard design with DC motors with an inlet through hull below the gunwale but not the bottom would work best. Inlets must be screened and capable of being cleaned from onboard.

Notes

- Goal 1: Nextgen mixed use barge must be capable of adoption within 5 years.
- Goal 3: Nextgen mixed use barge must be least cost, least risk.
- Goal 4: Nextgen mixed use barge must be hydrocarbon combustion free.
- Goal 5: Nextgen mixed use barge must be robust for >1M mile service life.
- All components must be capable of in place maintenance and replacement.
- All components or their associated critical duty items.
- All external power generated shall first charge on board batteries.
- All external power supplied shall be DC for barge needs.
- All mission critical replacement components must be local stocked.
- All onboard control systems to be hardened 24VDC.
- All onboard power systems to be DC.

- Deployment of said system into full operation shall not be more than five minutes from a dead start with charged batteries (insight).
- Power systems must be capable of 99%+ uptime operation.
- Power systems must be capable of sustained stand down or storage - on the order of months with no penalty (insight).
- Power systems must be fully capable of offline operation with no external access (insight).
- Power systems shall be capable of 24/7/90 day operation before significant onboard maintenance.
- Power systems must be easily integrated and coupled / decoupled with existing onboard drive systems.
- Said power systems batteries must be capable of providing at least +100% of peak demand for a 12-hour span (insight).
- Power systems must be of unitized construction and capable of 4-hour changeout in depot (insight).
- Said systems must provide enough power for mission critical sub systems.
- Startup external power supply shall be capable of 10-minute deployment support.
- Ultracapacitor or LiON components shall be capable of multiple recharges from the battery outputs.
- Ultracapacitor components shall be provided suitable for startup and local or brief operational needs (insight).
- Ultracapacitor output shall be on board DC and have amperages selectable at need (insight).
- Onboard motors shall use a vaporizable dielectric fluid for heating / cooling.

- Radiators for dielectric fluid cooling may be externally mounted on the barge gunwale or transom by serial connection (insight).
- Heating / cooling of the containers shall be by radiator chilling or EGT heating of the non-hazardous dielectric fluid which may be palm oil or a derivative (insight).
- All on-board process heat exhausts shall be vertical and common in a single stack.
- External control systems shall be optimized for both on time people and goods delivery at least cost and least risk.
- Non-standard hull design w rapid variable draft desirable for bottom clearance and flow conditions plus loading / unloading and near dock maneuvering (insight).
- RIB hull with draft maintained by inflation / deflation of air bladders (insight).
- Multiple articulated thrusters at stern, bow and amidships.
- RE powered via LiON batteries powered via solar PV and wind turbine (HAWT not VAWT) as horizontal axis wind turbine(s).
- LiON batteries powered propulsion by stern mounted water jets.
- NO EGT (expanding gas turbine) for this application for safety and mechanical simplicity requirements.
- Speed shall be current plus 2-3kn down or up.
- GC or Basalt fiber or Boron fiber for FRP hull and inflatable sponsons.
- Shallow draft is a must for inland freight barges.
- Draft to be < 5 feet in service which shall determine hull sizing.
- 20' ISO container to be standard sizing for packing / picking ease.

- All containers to be loaded perpendicular to direction of travel - e.g., beam to beam (insight).
- Automated port load / unload via straddle carrier highly desirable.
- Load / unload cycle shall not exceed 120 minutes.
- Stacks of ISO containers to be 2 or 3 high by 2 wide on a pre-loaded pack pallet of a standard configuration (insight).
- RFID tag or equivalent on container, contents and manifest.
- Staffing (if any) to be 3 or 6 personnel on 8 on /8 off schedule (insight).
- Between 24 and 30 containers shall fit the barge to capacity.
- Intermodal packing and packaging shall be consistent with no variance.
- People may be transported from port to port in specialized containers on upper decking only.
- End to end intermodal freight business model is highly desirable and would be highly disruptive.
- Assume that the Jones Act will continue to preclude foreign ownership.
- An E Musk type vision can make this happen not J Bezos' incremental growth vision.

CY2050 MARINE POWER GENERATION SYSTEMS

Publication date: January 20, 2020

Synopsis

Marine power generation became a focus when I began to understand how antiquated some current systems were. Disregarding nuclear powered warships and some turbine powered surface ships, current designs still combust bunker fuel, which is extremely inefficient and polluting, but it is inexpensive.

Given time and need that market will both shrink and need to become more efficient. That will necessitate a wholesale conversion to something new. My investigation revealed what that something new might be or at least could be.

This paper outlines that development. It is scaleable and would generate nearly no pollution for demonstrably least cost as well.

Introduction

The early adoption and then more widespread use of non-hydrocarbon energy sources that both save money and increase profitability is not a new idea for entrepreneurs, scientists, and governments. Everyone wants to innovate or create the latest big thing that pushes society forward toward a brighter future. Most of them have been fully proven to work but then no one deploys them for use until a vested second- or third-party controls it. Even then they often just catch and kill it. A cynical world view is useful when you are working toward disruptive technology, I think.

Blowing up that paradigm and making it to market requires using a highly efficient non-hydrocarbon energy source and closely integrated designs that are simple and cost efficient to deploy.

The concept as outlined below and included in the summary notes could accomplish this vital task as apparently none have before.

Packaging power generation, its associated power management and distribution is a surprisingly difficult to achieve goal when working to meet Marine, MilSpec or SmartGrid needs. It doesn't take much imagination to understand why this is a truism.

A sizeable resource and research publication library has been assembled and should be used accordingly if interest proves favorable.

This author has identified several applications that as mentioned above can readily be developed and deployed broadly. Marine powergen would be highly scaleable with modular units likely being developed in the 50 – 150 MW-h (or much more) range with high amperage DC available on a 24/7 basis for an integrated unit cost of ~ $400,000 – several million USD. Said units would be capable of sustained operation in all climactic conditions with industry standard uptimes and efficiency or much better. Commercial development monies can likely be provided by USDOD / DARPA and USDOE grants. Once decently proven up the private sector could conduct the rollout for a very substantial profit.

Reiterating, the target application for this summary report is power generation (powergen) for onboard marine (ship) needs that replaces the need for hydrocarbon or nuclear-powered systems for propulsion and other shipboard uses. It does however require a small volume of startup only dedicated compressed oxygen and hydrogen supplied by conventional means which are widely available at ports worldwide.

Replacing nuclear, diesel or other hydrocarbon fueled powergen system allows sustained operation for this application with many obvious implications for both military and civilian needs in the event of a sustained logistical supply chain disruption of any kind. The sun doesn't have to shine, the wind doesn't have to blow, and nuclear waste handling and disposal doesn't matter.

Concept

This power generation system will create its own fuels from atmospheric gases (hydrogen and oxygen) and then via a proven hydrogen / oxygen expanding gas combustion turbine drive to a coupled power generator that will charge a dedicated bank of sized for the application batteries (think TeslaWall). Said batteries will supply the DC local onboard grid on a demand basis. Offgrid but still local demand would be dealt with using portable ultracapacitors mounted on this system for charging/recharging. The system should be designed for 24/7/365-day operation with at least 12 months before first periodic port maintenance.

The forms of “emission” from this power generation system would be excess to need heat, disinfected drinking water, NOx, and CO2. The NOx and CO2 can be readily disposed of by dissolving them in excess to need shipboard water and then be wake dispersed with no environmental hazard or tracking issues. In a sense this represents a very stealthy powergen system.

Avoiding power generation output issues that can vary substantially with both ambient temperature and humidity requires the use of a high alloy intercooled two or three or more compressor stage set of serially piped turbines with supplemental water injection as needed. I do also advocate that these turbine sets be installed in parallel multiples to provide scaleable power and necessary backup.

An illustration of the basic process also with some notes by others is outlined below.

An excerpt from: Sanz, Wolfgang, Martin Braun, Herbert Jericha, and Max F. Platzer. "Adapting the Zero-Emission Graz Cycle for Hydrogen Combustion and Investigation of Its Part Load Behaviour." In *Turbo Expo: Power for Land, Sea, and Air*, vol. 49743, p. V003T06A020. American Society of Mechanical Engineers, 2016.

“PROCESS DESCRIPTION OF A GRAZ CYCLE PLANT FOR HYDROGEN COMBUSTION

Figure 1 shows the principle flow scheme of the Graz Cycle plant for hydrogen combustion, and Fig. 2 the associated temperature-entropy (T-s) diagram generated by the software IPSEpro. The plant is based on a proposal by Jericha [9] and consists basically of a high-temperature Brayton cycle and a low-temperature Rankine cycle – a combined cycle. The Brayton part consists of the combustion chamber (CC), the high-temperature turbine (HTT) and the compressors (C1/C2). The Rankine steam loop consists of the heat recovery steam generator (HRSG), high-pressure steam turbine (HPT), low pressure steam turbine (LPT), condenser,

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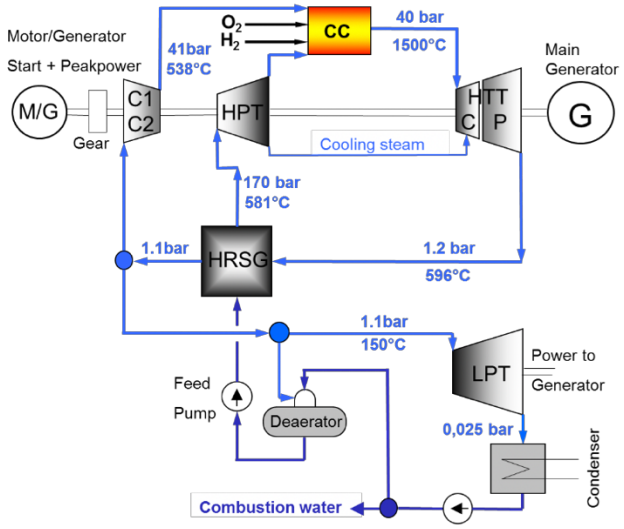


Fig. 1: Principle flow scheme of the Graz Cycle for hydrogen/oxygen combustion"

Maintaining consistent and predictable power generation is key for this process to work. The key is aggressive heat management as shown above.

An excerpt from: Abigail González-Díaz, Agustín M. Alcaráz-Calderón, Maria Ortencia González-Díaz, Ángel Méndez-Aranda, Mathieu Lucquiaud, Jose Miguel González-Santaló, Effect of the ambient conditions on gas turbine combined cycle power plants with post-combustion CO2 capture, Energy, Volume 134, 2017, Pages 221-233

"Generally, unlike the heat rate, the net power output from a gas turbine decreases with an increase of the ambient air temperature. This is due to reduced net power output, which is directly proportional to the air mass flow rate; net power produced decreases when the ambient air temperature increases. Practically, a 25% loss of the rated power capacity of the gas turbine at ISO conditions as the ambient temperature reaches 40 °C is reported."

Given that this process issue can be easily overcome by design then this concept then becomes compelling given the likely deployment locales. These locales will be highly variable and its effective mitigation of power loss by design becomes crucial.

In all instances all sub-systems are well proven. No new technology is required.

This author knows that a consistent and appreciable volume of relatively pure H2 / O2 are needed. My concept description for this is just below:

A blower driven raw atmosphere intake contacts a set of three sequentially mounted molecular sieves that would remove [1]water vapor, [2]methane/carbon dioxide and [3]nitrogen from the intake atmosphere volume. The “concentrated” downstream “gas” would be 90%+ oxygen would be compressed in a storage tank and directly used in the combustion process.

Then the molecular sieve separated [2]methane/carbon dioxide would be purged or cleaned from its’ molecular sieve using a small volume of the compressed oxygen on a timed basis. The purged volume of methane/carbon dioxide/oxygen would be captured, compressed, and then processed at low pressure (<2bar) and ambient temperature through a photoelectrochemically powered tubular or sheet assembled, optically clear, covered methane “reformer” or “cracker” to make a compressed hydrogen and oxygen product with a small volume of residual of carbon dioxide as a contaminant. The [1]water vapor molecular sieve would be similarly purged with the excess [3]nitrogen gas on a timed basis with the balance of the nitrogen vented to atmosphere.

Commercially this atmospheric gas separation can be described as a VSA, PSA or VPSA any of which could work. Commercial vendors for the appropriate molecular

sieve materials and the gas separation systems exist and should be thoroughly explored and then used as appropriate.

Maintenance needs are expected to be very low and should require nearly or no skilled labor to operate.

Commercially this system will be attractive from both a cost to construct and use (deploy) perspective especially when compared to either conventional or other unconventional energy systems. This option would keep the lights on and electronics working and properly disinfected drinking water flowing.

Alternatively, if the hydrogen supply is too small, compressed or cryogenic / liquid supplied methane / natural gas could be used although this would assume that some form of on demand logistic supply was available.

This author has previously specified use of magnetic bearings and transmissions for all applicable systems for similar, although smaller, applications. These are widely available and nicely sized for these applications which would eliminate most of the problems found with rotating machinery and their maintenance.

Again, this author does advocate close integration with other renewable energy generation and storage systems to increase supply optionality in the event of a national and / or regional grid outage of significant duration.

Notes

- All components must be capable of in place maintenance and replacement.
- All components or their associated critical duty items.
- All external power generated shall first charge on board batteries.
- All external power supplied shall be DC or AC for HVAC needs.
- All mission critical replacement components must be local stocked.
- All onboard control systems to be hardened 24VDC.
- All onboard power systems to be DC (insight).
- Batteries shall be capable of distribution and load balancing.
- CO2 sequestration for this application is contraindicated.
- Deployment of said system into full operation shall not be more than ten minutes from a dead start with charged batteries (insight).
- Atmospheric emissions shall be low temperature water vapor and trace amounts of NOx well below background levels (insight).
- Water emission of CO2 shall be dissolved, and wake dispersed well below background levels (insight)
- H2/O2 expanding gas turbine power generation must be capable of supplying all on board power needs plus at least 25% of peak demand into the on-board storage battery / ultracapacitor banks.
- H2/O2 heat recovery shall be recycled for pre-heat and methane reformer needs then vented to atmosphere.
- H2/O2 vent shall have provision for drinking water supply from a dedicated supply tank.
- H2/O2 water supply shall have on board NaOCl generation from "table" salt and dosing hardware for disinfection of the supply tank (insight).
- Shipboard AC /HVAC qualify for integration with a 6 - 10% inversion penalty.

- Methane cracker must be capable of providing at least a 50%+ hydrogen product @ 2 bar pressure (insight).
- Methane cracker can use as fuel sources:
    - Liquid water (sheet or tube (insight) configured)) using:
        - Liquid water with saturated dissolved methane (insight)
        - Gaseous methane and entrained but not required CO2 within an optically clear shell and tube arrangement (insight).
- Power systems must be capable of 99%+ uptime operation.
- Power systems must be capable of sustained stand down or storage - on the order of years with no penalty (insight).
- Power systems must be fully capable of offline no external access (insight).
- Power systems (preferably 3 or more - 50MW or more units) shall be capable of 24/7/90 day operation before significant onboard maintenance.
- Molecular sieve materials must be fines removal pre-sieved then triple bagged with an appropriated desiccant for long-term on-board storage.
- PSA / VPSA or VSA must provide a 90%+ gaseous O2 product @ 2 bar pressure.
- PSA / VPSA or VSA must provide a 90%+ methane / CO2 blended product @ 2 bar pressure.
- PSA / VPSA or VSA must provide a 90%+ nitrogen product.
- Power systems must be easily integrated and coupled / decoupled with existing onboard drive systems.
- Power system turbines should be two or more output shaft capable to provide flexibility in drive and onboard power system integration and / or repair while at sea.

- Said power systems batteries must be capable of providing at least +50% of peak demand for a 4-hour span (insight).
- Power systems must be of unitized construction and capable of 4-hour changeout in port, not drydock (insight).
- Said systems must provide enough power for mission critical sub systems.
- Startup external power supply shall be capable of 10-minute deployment support.
- Ultracapacitor components shall be capable of multiple recharges from the battery outputs.
- Ultracapacitor components shall be provided suitable for startup and operational needs.
- Ultracapacitor output shall be on board DC or AC voltage / amperage selectable (insight).

N+5 AUTONOMOUS UNDERWATER VEHICLES

Publication date: December 30, 2020

Synopsis

This report was a response to an RFP that I reviewed in late 2020. As I researched the topic, I began to understand that the transition to AUV's would be difficult because our society and how we perceive underwater operations still reflected a bias toward terrestrial constructions. I determined that a break with that bias could yield an interesting design capable of many functions not envisioned in the RFP.

So, it became an "out of the box" thought experiment. I do admit other work by myself not pertinent to this publication, at the time, gave me some insights as well.

A design concept like this would have to be developed, tested, and deployed with care. It was a turning point for me toward planetary engineering though. Also, it put me on the path toward investigating methane hydrates, their mining, in-situ CO2 replacement and oceanic alkalinity enhancement.

Introduction

The early adoption and then more widespread use of novel technology that both save money and increase performance is not a new idea for entrepreneurs, scientists and governments and is a goal they aspire to achieve. Everyone wants to innovate or create the latest big thing that pushes society forward toward a yet

brighter future. Most (not all) of them have been fully proven to work but then no one deploys them for use until a vested second- or third-party controls it. Even then they often make a minor investment to just catch and kill it. A cynical world view is useful when working with mature society's, their politics, diplomacy, and their perspectives, I think.

Blowing up that paradigm and making it to market requires the use of easily adopted stepchange technologies that offer's least cost operation for least risk with enhanced performance. This simple strategy certainly applies in autonomous underwater vehicle development and deployment just as it applies to most markets. In this instance this strategy encompasses using a highly efficient, naturally occurring, non-hydrocarbon energy source to only keep the onboard batteries charged and other closely integrated design concepts that already exist. Above all else, those technologies that are simple, effective, and cost efficient to prove up and then deploy were chosen.

The strategy as outlined below and further captured in the associated summary notes could accomplish this increasingly vital task as apparently none have before. Answering "why" might be vital this point. Why – because we are now rapidly transitioning into a diplomatic "great power" set of scenarios that promise a return of "cold war" strategy and tactics. At least that is the case from my daily defense related news feeds lead me to believe. Also being in the grip of a global pandemic (likely to become a series) that has changed and largely disrupted our global economy in a staggeringly short period of time also opens the door for this type of approach – which is largely set it and forget it with some inputs occasionally needed. This type of global strategy could well use this author's

modest work as outlined herein to positive effect as a portion of that strategy. That portion allows hydrocarbon free on-board energy generation / no external fuel supply except seawater / no nuclear power supply / long mission and patrol distance duration with effective strike or defense capabilities for least cost / least risk. What could go wrong? A lot can go wrong though and that why it needs to be proven up, but it could work well.

First, some background needs to be defined and explored. That is, as is usual for me, best outlined by others with some inputs by me.

An excerpt from: Leenes, Ronald, Erica Palmerini, Bert-Jaap Koops, Andrea Bertolini, Pericle Salvini, and Federica Lucivero. "Regulatory challenges of robotics: some guidelines for addressing legal and ethical issues." *Law, Innovation and Technology* 9, no. 1 (2017): 1-44.

"Unmanned underwater vehicles (**UUV**), sometimes known as **underwater drones**,[1] are any vehicles that are able to operate underwater without a human occupant. These vehicles may be divided into the two categories of remotely operated underwater vehicles (ROUVs), which are controlled by a remote human operator, and autonomous underwater vehicles (AUVs), which operate independently of direct human input (I advocate for AUV's – author). Sometimes only vehicles in the second category are considered a kind of robot, but those in the first category are also robots similar to surgical robots, which also mostly require an operator.

Applications

AUV REMUS (front) and Seafox (rear)

Another excerpt from: SEA MINES AND NAVAL MINE COUNTERMEASURES: ARE AUTONOMOUS UNDERWATER VEHICLES THE ANSWER, AND IS THE ROYAL CANADIAN NAVY READY FOR THE NEW PARADIGM? Lieutenant-Commander J. Greenlaw, Sea mines and naval mine countermeasures

The navies of multiple countries, including the US, UK, France, Russia, and China[2] are currently creating unmanned vehicles to be used in oceanic warfare to discover and terminate underwater mines. For instance, the REMUS is a three-foot long robot used to clear mines in one square mile within 16 hours.[3] This is much more efficient, as a team of human divers would need upwards of 21 days to perform the same task. In addition to UUVs with the purpose of clearing out mines, autonomous submarines began to be prototyped as of 2008.[4] Especially autonomous submarines face much of the same ethical issues as other unmanned weapons.[4] Other applications include ship hull inspection (Bluefin),[5] wreck inspection (Blueye Pioneer),[6] nuclear reactor decontamination, exploration, and mining/drilling.

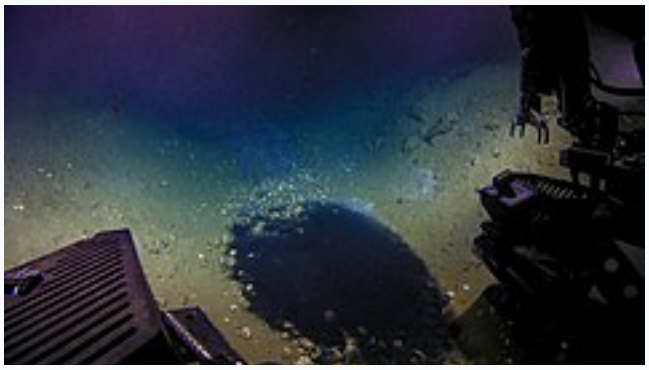
Unmanned underwater vehicles have other potential military applications. A survey conducted by RAND Corporation for the US military analyzed the missions which unmanned underwater vehicles could perform, which included intelligence, reconnaissance, mine countermeasures, and submarine warfare (this is what this author is targeting as its applications). The review listed these from most to least important.[7]

OODA Technologies, a data collection and analysis company, is highly interested in utilizing UUVs along the coasts of Canada. According to OODA,[8] these unmanned craft provide much greater coverage of an area at a much lower cost. The quality of the data returned by unmanned marine vehicles is also stated to be much higher than that of traditional manned craft.[*citation needed*]

Deep-sea exploration and research[edit]

Main article: Deep-sea exploration § Unmanned submersibles

A video describing the operation and use of a remotely operated vehicle (ROV) in deep sea research.



A ROV at 1,067 meters depth.

Unmanned underwater vehicles can be used for deep-sea exploration and research (NOT what this author has in mind). For example remotely operated vehicles have been used to collect samples from the sea-floor to measure its microplastics-contents,[9] to explore the deep-sea fauna and structures and discovering new underwater species.[10][11]

UUVs are commonly used in oceanic research, for purposes such as current and temperature measurement, ocean floor mapping, and Hydrothermal vent detection. Unmanned underwater vehicles utilize seafloor mapping, bathymetry, digital cameras, magnetic sensors, and ultrasonic imaging. The Woods Hole Oceanographic Institution employs a vehicle called the Sentry, which is designed to map the ocean floor at depths of six thousand meters. The vehicle is shaped to minimize water resistance during dives and utilized acoustic communications systems to report the vehicles status while operating. Unmanned underwater vehicles are capable of recording conditions and terrain below sea ice, as the risk of sending an unmanned vehicle into unstable ice formations is much lower than that of a manned vessel. Glider type unmanned vehicles are often used to measure ocean temperatures and current strengths at various depths. Their simplicity and reduced operating costs allow more UUVs to be deployed with greater frequency, increasing the accuracy and detail of ocean weather reporting. Many UUVs designed with the purpose of collecting seafloor samples or images are of the

towed type, being pulled by a ship's cable along either the seafloor or above. Towed vehicles may be selected for tasks which require large amounts of power and data transmission, such as sample testing and high-definition imaging, as their tow cable serve as the method of communication between controller and craft. Science Direct claims the use of Unmanned Underwater Vehicles has risen consistently since they were introduced in the 1960s and find their most frequent use in scientific research and data collection. Oceanservice describes Remote Operated Vehicles (ROVs) and Autonomous underwater vehicle (AUVs) as two variations of UUVs, each able to accomplish the same tasks, provided the craft is properly designed.[citation needed]

Implementations

These examples of applications took place during the fourth iteration of the Advanced Naval Technology exercises, in August at the Naval Undersea Warfare Center Division Newport. The first example of unmanned underwater vehicles was displayed by Northrop Grumman with their air drop sonobuoy's from a fire scout aircraft. Throughout the demonstration the company used the: e Iver3-580 (Northrop Grumman AUV) to display their vehicles ability to sweep for mines, while also displaying their real-time target automated recognition system. Another company, Huntington Ingalls Industries, presented their version of an unmanned underwater vehicle named Proteus. The Proteus is a dual-mode undersea vehicle developed by Huntington and Battelle, the company during the presentation displayed their unmanned underwater vehicle capabilities by conducting a full-kill demonstration on seabed warfare. During the demonstration the vehicle utilized a synthetic aperture sonar which was attached to both the port and starboard of the craft, which allowed the unmanned underwater vehicle to identify the targets placed underwater and to ultimately eliminate them (may be useful but needed power levels might preclude them – this author). Ross Lindman (director of operations at the company's technical solution's fleet support group) stated that "The big significance of this is that we ran the full kill chain"[citation needed]. "We ran a shortened version of an actual mission. We didn't say, 'Well we're doing this part and you have to imagine this or that.' We ran the whole thing to illustrate a capability that can be used in the near term."[citation needed] The final demonstration for unmanned underwater vehicles was displayed by General Dynamics, the company showcased their cross-domain multi-platform UUV through a theater simulating warfare planning tool. Through the utilization of this simulation, they showed a Littoral combat ship along with two unmanned underwater vehicles. The goal of this exercise was to demonstrate the communication speed between the operator and the UUV. James Langevin, D-R.I., ranking member on the House Armed Services Committee's subcommittee on emerging threats, stated in regard to this exercise "What this is all driving to is for the warfare commander to be able to make the decisions that are based on what he thinks is high-confidence input quicker than his adversary can," (with extreme stealth and lethality using an AUV – this author) he said. "That's the goal — we want to be able to … let them make warfare-related decisions quicker than anybody else out there."[citation needed] These exercises were conducted to showcase the applications of unmanned underwater vehicles within the military community, along with the innovations each company created to better suite these specific mission types.[citation needed]

Concerns

A major concern with unmanned underwater vehicles is communication. Communication between the pilot and unmanned vehicle is crucial, however there are multiple factors that might hinder the connection between the two. One of the major problems involves the distortion of transmissions underwater, because water can distort underwater transmissions and delay them which can be a very major problem in a time sensitive mission. Communications are usually disturbed due to the fact that unmanned underwater vehicles utilize acoustic waves rather than the more conventional electromagnetic waves. Acoustic wave transmissions are often delayed anywhere from 1–2 seconds because they move more slowly than other types of waves. This is not including environmental conditions that can also hinder communications such as reflection, refraction, and the absorbing of signal. These effect within the water overall scatter and degrade the signal, making this communication system fairly delayed when compared to other communication sources.[12] Another system that utilizes the acoustic waves is within the navigation of these unmanned vehicles, precise navigation is a must for these unmanned vehicles to complete their missions. A popular navigation system aboard these unmanned underwater vehicles is acoustic positioning, which is also faces with the same problems as acoustic communication because they use the same system (this author may have the answer for these issues – outlined in the summary notes section). The Royal Netherlands Navy has published an article[13] detailing their concerns surrounding unmanned marine vehicles. The Royal Netherlands Navy is strongly concerned with the ability of UUV's to evade detection and complete tasks not possible in manned vessels. The adaptability and utility of Unmanned Underwater vehicles means it will be difficult to predict and counter their future actions.[*citation needed*] In the last years, projects like TWINBOT are developing new ways of communication among several GIRONA500 AUVs."[14]

Another topic best covered by others is summarized below.

An excerpt from: Oraizi, Homayoon, Ali Abdolali, and Noushin Vaseghi. "Application of double zero metamaterials as radar absorbing materials for the reduction of radar cross section." *Progress In Electromagnetics Research* 101 (2010): 323-337.

"We introduce and investigate the applications of double zero (DZR) metamaterials (having the real parts of permittivity and permeability equal to zero) as radar (or sonar – this author) absorbing materials (RAMs). We consider a perfectly electric conductor (PEC) plate covered by several layers of DZR metamaterial coatings under an oblique plane wave incidence of arbitrary polarization. Several analytical formulas are derived for the realization of zero reflection from such structures. The angle of reflection in the DZR metamaterials becomes complex, which leads to the dissociation of the constant amplitude and equiphase planes. Then several examples of the applications of DZR metamaterials (in nondispersive and dispersive conditions) as RAMs and zero reflection

coatings are provided. The characteristics and parameters of the DZR metamaterial media are determined in each case. The method of least squares is used to optimize the DZR coatings for the minimization of reflected power, which uses the combination of genetic algorithm and conjugate gradient method (GA-CG) to benefit from their advantages and avert their short comings."

A relevant perspective by others that I picked out of a recent "Foreign Affairs" article from which an excerpt is below:

"Climate change is often described as a "wicked problem" meaning that it resists easy definition and defies conventional solutions. It transcends political boundaries and cannot be solved by a single country, but international governance is a weak substitute. It is a collective action problem that demands a collective solution, but it has instead led to a great deal of finger pointing." Also, "In short, humanity uses the atmosphere as a free dumping ground for pollutants, and deeply vested interests resist changing that."

Why I would mention this quote is answered very simply. Climate change will make the desperate do desperate things. Be prepared for that stance by other powers, plan for it and respond to it in an oceanic and littoral environment that might well preclude other more normal answers.

A sizeable resource and research publication library has been assembled and should be used accordingly if interest proves favorable.

Making this delivery and reconnaissance system requires use of robust, simple, and efficient design concepts that offers least cost and least risk. Going faster and deeper with yet more tonnage on board isn't a viable answer especially when our society is going through wrenching changes due to climate change, pandemics and increasing resource scarcity. This concept I am outlining can be proven up quickly and deployed very broadly to best effect. At least that is my belief.

Replacing conventional undersea systems for a least cost, least risk and highly flexible delivery and reconnaissance system offers obvious benefits. Affording to do a large-scale program of this type can be easily done using the USDOD tax model this author has outlined many times in the recent past.

The sun doesn't have to shine, the wind doesn't have to blow, and the munitions get delivered in an accurate, timely manner with stealth.

Concept

This power generation system will create its own fuels from atmospheric gases (hydrogen and oxygen) gathered from seawater electrolysis and then via a proven hydrogen / oxygen expanding gas combustion turbine directly coupled to a power generator that will, in turn, charge a dedicated bank of sized for the application batteries (think TeslaWall). Said batteries will supply the AC or DC local onboard needs including propulsion on a demand basis. The system can be designed for 24/7/365-day operation with global mission delivery.

The forms of "emission" from this power generation system would be excess to need heat which can be vented overboard as warm water.

Avoiding power generation output issues that can vary substantially with both ambient temperature, depth and humidity requires the use of a high alloy intercooled two or three or more compressor stage set of serially piped LOPR turbines with supplemental water injection as needed. I do also advocate that

these turbine sets be installed in parallel multiples (probably two) to provide scaleable power and necessary backup working from an excess of caution.

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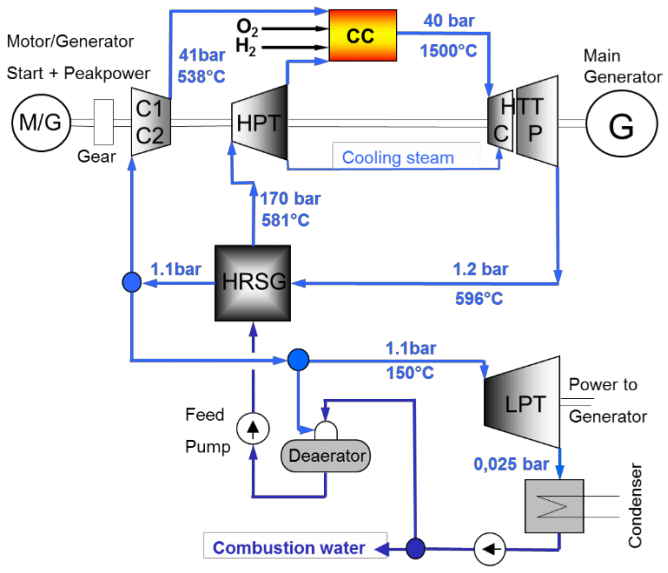


Fig. 1: Principal flow scheme of the Graz Cycle for hydrogen/oxygen combustion"

Maintaining consistent and predictable power generation is key for this process to work. The key is aggressive heat management as shown above.

Put another way from the same source: "Generally, unlike the heat rate, the net power output from a gas turbine decreases with an increase of the ambient air temperature. This is due to reduced net power output, which is directly proportional to the air mass flow rate; net power produced decreases when the ambient air temperature increases. Practically, a 25% loss of the rated power capacity of the gas turbine at ISO conditions as the ambient temperature reaches 40 °C is reported."

Given that this process issue as described above can be easily overcome by design then this concept then becomes compelling given the application at hand.

In all instances all sub-systems are well proven. No new technology is required.

This author knows that a consistent and appreciable volume of relatively pure H2 / O2 are needed. He also knows that the US Navy knows how to design and deploy highly efficient seawater electrolysis cells in an on-board environment.

Commercially this system will be attractive from both a cost to construct and use (deploy) perspective especially when compared to either manned or unmanned conventional or unconventional energy systems.

Alternatively, if the onboard hydrogen supply is too small, compressed methane or natural gas could be used although this would assume that some form of onboard, on demand quality fuel was available. My hope is that if as proven up it is not necessary. If LNG or similar is not available, then compressed H2 may be used. Double wall monolithic austenitic SS tanks are the likely best choice. Said tanks may be fuselage mounted for ease of access and maintenance. Gaseous transfer pumps should likely be of ceramic design.

This author has previously specified use of magnetic bearings and transmissions for all applicable systems for similar, although smaller, applications. These are widely available and nicely sized for these applications which would eliminate most of the problems found with rotating machinery and their maintenance.

Notes

- This unmanned, undersea vessel shall have NO provision for personnel access.
- This author proposes a no pump desalination system that shall function in an operating depth range of 1000 – 2000’ (insight).
- Hydrodynamic pressure generated by vessel thrust system shall drive reverse osmosis (RO) operation e.g., no feed pump to create an organic and nearly salt free permeate suitable for further processing (insight).
- Irised and articulated (variable diameter) opening which is normally closed into outer hull interior then fixed diameter RO opening for inner pressure hull (insight).
- An outer hydrodynamically efficient hull which is DZR fully coated as its RAM shall not be a pressure hull but instead shall function as a semi-flexible lightweight stealthy hull form and will be fully flooded (insight).
- Outer hull shall have GC or BC struts and spars sufficient to maintain its shape in any operational situation with bonding to inner hull via imbedded mechanical hinges and shearable pins (insight).
- Outer hull may have hull “panels” with forward osmosis membranes imbedded of sufficient area to provide interhull “space” with forward osmosis (FO) filtered seawater largely devoid of organic contaminants of sufficient quality to optimize the downstream process RO system (insight).
- RO system shall be flat sheet configuration suitably sized for on demand operation for the lifetime of the vessel’ mission duration.
- FO filtration shall be driven by hydrodynamic pressure on outer hull surface (insight).

- RO reject brine pump shall be omitted with discharge directly overboard (insight).
- Cross elliptical shaped submersible pressure hulls of neutral buoyancy e.g., “pearls on a string” with a minimum number of through hull perforations that may not exceed 2 or at most 3 of small diameter and not to exceed 75 – 90mm.
- CSi foamed interiors of inner pressure hull sphere(s) which can be composed of either graphite or boron composite which may be ~2M in diameter.
- “Pearls on a string pressure hull” spheres to be 1) RO/E-Cell, 2) MS/EGT, 3) AI/Comms, 4) Turbine/Trans/Propulsion (insight).
- RO permeate shall be piped direct to an electrolysis cell (E-Cell) within the same CSi foamed with a GC layup inner pressure hull as the first “pearl” in a string of pearls pressure hull arrangement (insight).
- E-Cell shall have a headspace under pressure sufficient to collect a blend of gaseous H2 and O2 in a downstream process head space vent pressure vessel with a solenoid (NC) inlet and solenoid (NC) outlet (insight).
- Collected O2/H2 shall be supplied to the onboard pressure hull protected expanding gas combustion turbine via the NC outlet solenoid (EGT) for the “top up” of on-board battery system (insight).
- Said on board battery system to provide control and communications power, an articulated and shrouded impeller system and various externally mounted control surfaces sufficient to allow autonomous operations.
- Propeller or pumped thrust drive with its magnetic transmission shall be in its own pressure sphere.

- Missiles = torpedo's = submerged cruise missiles capable of high precision strike using INS with no GPS or other inputs.
- Vessel may be designed for sprint speed at 30 – 50 kt for not more than 45 minutes to possibly as long as an hour.
- Operating speed to be 5 – 10 kt on a sustained basis.
- Mission duration may be 3 – 6 months or more.
- Cross section of hull to be generally cylindrical of DZR or better coated woven with a sonar cross section of not more than 0.5M at most.
- DZR coated GC or BC shrouded and supported cruise missile (CM) pods strung on articulating pylons of a fixed length shall be strung about the vessels center of gravity to provide enhanced stability and maneuverability (insight).
- Woven GC or BC outer hull to be coated with DZR or similar materials with no appreciable sonar permeability and no permissivity.
- Inner pressure hull shall be coated with DZR or similar materials of sufficient depth and adherence to offer no appreciable sonar permeability or and no permissivity (insight).
- NEED wide band RAM materials for both inner and outer hull coatings as an operational imperative such as DZR materials.
- Alternative propulsion could be articulated pumped jet propulsion
- Siemens Permasyn motor sized for either 4 or 6Mw exist and can be easily integrated in this authors opinion.
- Control surfaces (if any) would be flexible fin types with GC or BC fin rays for shaping or station keeping but not thrust per se (insight).
- DZR or RAM surface could also be surface coated with superhydrophobic coatings to enhance thrust and thus mission duration (insight).

- Distributed computing within the main system with smart cruise missile architecture would permit mission continuance until a signaled or “ammo out” end.
- Distributed computing within the main system, articulating pylons and CM shroud would also be useful to permit mission continuance and possibly outer hull shaping to permit enhanced mission continuance (insight).
- Sperm whale pod as a vessel or “drone” swarm with fairly routine porpoising for commo / nav and venting of excess moisture (if any) and possibly intake of “dry” air for headspace evacuation for E-Cell needs may be advantageous.
- Swarm of vessels shall communicate via sperm whale “clicks” on a precision but variable timed basis with each vessel having a unique signature.
- Said “clicks” shall have no meaning per se with the period between click “strings” containing the message.
- Survivability shall include electromagnetic pulse (EMP), over pressure and shock or impacts.
- Networked OR autonomous UUV’s with robust and adaptive routing may be highly desirable especially for mapping and delivery purposes.
- Outer pressure hull shall have 2 or 3 additional delivery devices arranged radially as alternatives.
- CM “pods” to be frangible and capable of jettison on command.
- Whole vessel shall be capable of rotating CM pods to distribute loads e.g., 1 fired etc
- When CM pod is fired its pylon is jettisoned via “click” bolts to maintain stealth.

- Possible alternative shall be electromag pylon attachment with after shot drop off.
- CM pod may be jettisoned whole with its onboard load being of neutral buoyancy and being capable of limited station keeping.
- CM pod may also have radial thrusters in vertical plane and that would be capable of modest orientation changes while station keeping.

PRACTICAL INPUTS FOR HYPERLOOP TRANSPORT

Publication date: Friday, November 20, 2020

Synopsis

I investigated this topic with a certain amount of interest and a certain amount of disbelief. Published research documents were few and far between. Interest was high by the public and to a limited degree by the venture capital community. Progress toward a functional and safe design seemed far too easy to be valid.

After a great deal of thought I decided to pursue it primarily from a safety perspective. Knowing full well my thoughts were not too likely to ever be read.

After an inordinate amount of research, I found out, though, that I had a lot to say. Most of my insights pertain to functionality and safety.

I do doubt that this will ever be done. But, who knows, it could be done someday. If it happens at least do it safely.

Introduction

The early adoption and then more widespread use of transportation systems that both save money and increase profitability is not a new idea for entrepreneurs, scientists and governments and is a goal they aspire to achieve. Everyone wants to innovate or create the latest big thing that pushes society forward toward a yet brighter and safer future hopefully for a large profit.

I have taken that paradigm and pushed it yet another step forward by offering some inputs that may take the Hyperloop Transport concept a few steps closer to reality. Also, I normally espouse the adoption of stepchange technologies that can offer least cost operation for least risk without the need for hydrocarbon energy sources. In this instance that is certainly true.

This conceptual strategy encompasses using a highly efficient non-hydrocarbon energy source and other closely integrated emerging technologies that already exist and that can, when combined, bring the Hyperloop to life rapidly. It may not offer the large profits for existing stakeholders that are usually an expectation, but even then, most would endorse a least cost, least risk approach that offers a predictable profit. Some others may attempt a catch and kill approach regardless because change is a risk, and they are deeply vested in alternatives.

Answering “why” would I do this conceptual effort might be vital this point. Why – because we are in the grip of a global pandemic that has changed and largely disrupted our global economy in a staggeringly short period of time. Finding the way to recover our economy and its various supply chains while also conquering the pandemic (and others yet to come) becomes a first order priority. This dire situation could use this author’s modest work as outlined herein to positive effect as a portion of a recovery strategy if even in a small way.

A sizeable resource and research publication library has been assembled and should be used accordingly if interest proves favorable.

Replacing hydrocarbon fueled powergen systems that also allow for sustained operation with a simple, easily maintained system has many obvious implications for both market development and rollout and its profitability. Affording to do the development and rollout can be easily done using the energy tax model this author has outlined many times in the recent past.

Concept

An Hyperloop explanation is below. It may be helpful:

"The **Hyperloop** is a proposed mode of passenger and freight transportation, first used to describe an open-source vactrain design released by a joint team from Tesla and SpaceX.[1] Hyperloop is a sealed tube or system of tubes with low air pressure through which a pod may travel substantially free of air resistance or friction.[2] The Hyperloop could convey people or objects at airline or hypersonic speeds while being very energy efficient.[2] This would drastically reduce travel times versus trains as well as planes[2] over distances of under approximately 1,500 kilometers (930 miles).[3]

Elon Musk first publicly mentioned the Hyperloop in 2012.[4] His initial concept incorporated reduced-pressure tubes in which pressurized capsules ride on air bearings driven by linear induction motors and axial compressors.[5]

The Hyperloop Alpha concept was first published in August 2013, proposing and examining a route running from the Los Angeles region to the San Francisco Bay Area, roughly following the Interstate 5 corridor. The Hyperloop Genesis paper conceived of a hyperloop system that would propel passengers along the 350-

mile (560 km) route at a speed of 760 mph (1,200 km/h), allowing for a travel time of 35 minutes, which is considerably faster than current rail or air travel times. Preliminary cost estimates for this LA–SF suggested route were included in the white paper—US$6 billion for a passenger-only version, and US$7.5 billion for a somewhat larger-diameter version transporting passengers and vehicles.[1] (Transportation analysts had doubts that the system could be constructed on that budget. Some analysts claimed that the Hyperloop would be several billion dollars overbudget, taking into consideration construction, development, and operation costs.)[6][7][8]

The Hyperloop concept has been explicitly "open-sourced" by Musk and SpaceX, and others have been encouraged to take the ideas and further develop them. To that end, a few companies have been formed, and several interdisciplinary student-led teams are working to advance the technology.[9] SpaceX built an approximately 1-mile-long (1.6 km) subscale track for its pod design competition at its headquarters in Hawthorne, California.[10] Virgin Hyperloop conducted the first human trial with Virgin Hyperloop executives Josh Giegel, its Chief Technology Officer, and Sara Luchian, Director of Passenger Experience as the first passengers at a speed of 172 km/h (107 mph) at the Virgin Hyperloop's DevLoop test site in Las Vegas, Nevada.[11][12]".

My concept integrates both on board powergen using an expanding gas turbine combusting gaseous hydrogen and oxygen and on-board battery supply. Externally, acceleration, cruise and deceleration would be via coilgun type electromagnetic coils and maglev type suspension systems. E-stop and battery supply would be via on board EGT and short duration exhaust nozzle suspension. Braking would be eddy current in all operational modes.

My (not new nor solely my own) power generation system will create its own fuels from atmospheric gases (hydrogen and oxygen) present in the transport tube. Then via a proven hydrogen / oxygen expanding gas combustion turbine drive to a coupled power generator that will charge a dedicated bank of sized for the application batteries (think TeslaWall). Said batteries will supply the AC local onboard grid on a demand basis. The system can be designed for 24/7/365-day operation with at least 12 months before first periodic port maintenance.

The forms of “emission” from this power generation system would be excess to need heat and water. Heat and water will need to be controlled within the tube and its capsule anyhow. I expect this small, intermittent source will be of no concern.

An illustration of the basic EGT process also with some notes by others is below:

An excerpt from: Sanz, Wolfgang, Martin Braun, Herbert Jericha, and Max F. Platzer. "Adapting the Zero-Emission Graz Cycle for Hydrogen Combustion and Investigation of Its Part Load Behaviour." In *Turbo Expo: Power for Land, Sea, and Air*, vol. 49743, p. V003T06A020. American Society of Mechanical Engineers, 2016.

“PROCESS DESCRIPTION OF A GRAZ CYCLE PLANT FOR HYDROGEN COMBUSTION

Figure 1 shows the principal flow scheme of the Graz Cycle plant for hydrogen combustion, and Fig. 2 the associated temperature-entropy (T-s) diagram generated by the software IPSEpro. The plant is based on a proposal by Jericha [9] and consists basically of a high-temperature Brayton cycle and a low-

temperature Rankine cycle – a combined cycle. The Brayton part consists of the combustion chamber (CC), the high-temperature turbine (HTT) and the compressors (C1/C2). The Rankine steam loop consists of the heat recovery steam generator (HRSG), high-pressure steam turbine (HPT), low pressure steam turbine (LPT), condenser, condensate pump, deaerator and finally the feed pump supplying high pressure water to the HRSG.

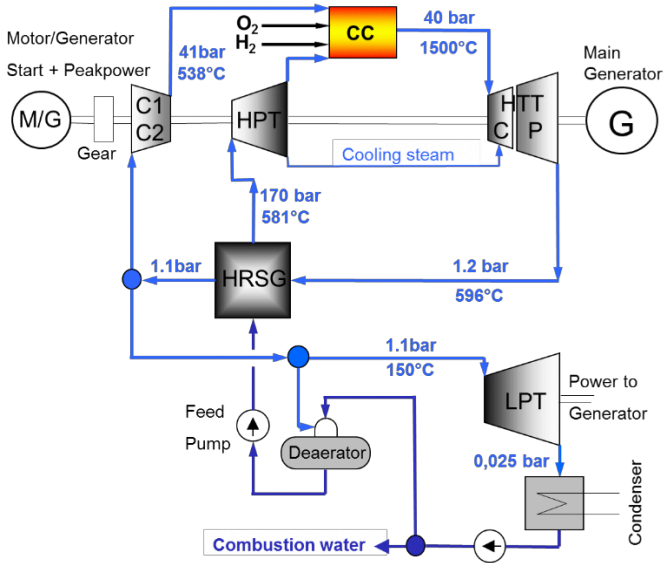


Fig. 1: Principal flow scheme of the Graz Cycle for hydrogen/oxygen combustion"

Maintaining consistent and predictable power generation is key for this process to work. The key is aggressive heat management as shown above.

Put another way: "Generally, unlike the heat rate, the net power output from a gas turbine decreases with an increase of the ambient air temperature. This is due to reduced net power output, which is directly proportional to the air mass flow rate; net power produced decreases when the ambient air temperature increases. Practically, a 25% loss of the rated power capacity of the gas turbine at ISO conditions as the ambient temperature reaches 40 °C is reported."

Given that this process issue can be easily overcome by design then this concept then becomes compelling given the application at hand.

In all instances all sub-systems are well proven. No new technology is required.

This author knows that a consistent and appreciable volume of relatively pure H2 / O2 are needed. My concept description for this is just below as text (see next page):

A compressor driven raw atmosphere intake contacts a set of three sequentially mounted molecular sieves that would remove [1]water vapor, [2]methane/carbon dioxide and [3]nitrogen from the intake atmosphere volume. The "concentrated" downstream "gas" would be 90%+ oxygen would be compressed in a storage tank and directly used in the combustion process.

Then the molecular sieve separated [2]methane/carbon dioxide would be purged or cleaned from its' molecular sieve using a small volume of the compressed oxygen on a timed basis. The purged volume of methane/carbon dioxide/oxygen would be captured, compressed, and then processed at low pressure (<2bar) and ambient temperature through a photoelectrochemically powered tubular or sheet assembled, optically clear, covered methane "reformer" or "cracker" to make a compressed hydrogen and oxygen product with a small volume of residual of carbon dioxide as a contaminant. The [1]water vapor molecular sieve would be similarly purged with the excess [3]nitrogen gas on a timed basis with the balance of the nitrogen vented to the tube's atmosphere and then vented as outline in my attached notes.

Commercially this atmospheric gas separation can be described as a VSA, PSA or VPSA any of which could work. Commercial vendors for the appropriate molecular sieve materials and the gas separation systems exist and should be thoroughly explored and then used as appropriate.

Commercially this system will be attractive from both a cost to construct and use (deploy) perspective especially when compared to either conventional or other unconventional (renewable) energy systems.

Alternatively, if the onboard hydrogen supply is too small, compressed methane or natural gas could be used although this would assume that some form of on demand logistic supply was available.

This author has previously specified use of magnetic bearings and transmissions for all applicable systems for similar applications. These are widely available and nicely sized for these applications which would eliminate most of the problems found with rotating machinery and their maintenance.

Again, this author does advocate close integration with other renewable energy generation and storage systems to increase supply optionality in the event of a national and / or regional grid outage of significant duration.

Notes

Goals:

- Goal 1: Nextgen mixed use hyperloop tube and capsule is the innovation target for this effort.

- Goal 2: Nextgen mixed use hyperloop tube and capsule must be capable of first beneficial use within 5 years.
- Goal 3: Nextgen mixed use hyperloop tube and capsule must be least cost, least risk.
- Goal 4: Nextgen mixed use hyperloop system must be hydrocarbon combustion free.
- Goal 5: Nextgen mixed use hyperloop tube and capsule must be robust for >1M mile service life.
- Goal 6: Nextgen mixed use hyperloop tube and capsule must be operable in all topography's and climates.
  - All components must be capable of in place maintenance and replacement.
  - All components or their associated critical duty items.
  - All external power generated shall first charge on board batteries.
  - All external power supplied shall be AC for capsule operational needs.
  - All mission critical replacement components must be local stocked.
  - All onboard control systems to be hardened 24VDC.
  - All onboard power systems to be AC.
  - Deployment of said system into full operation shall not be more than one minute from a dead start with charged batteries (insight).
  - Atmospheric emissions shall be low temperature water vapor and trace amounts of NOx and CO2 well below background levels (insight).
  - H2/O2 expanding gas turbine power generation must be capable of supplying all on board power needs plus E-stop requirements plus at least 25% of peak demand into the on-board storage battery / ultracapacitor banks.

- Onboard AC /HVAC needs qualify for integration with a 6 - 10% inversion penalty.
- Power systems must be capable of 99%+ uptime operation.
- Power systems must be capable of sustained stand down or storage - on the order of years with no penalty (insight).
- Power systems must be fully capable of offline no external access operation (insight).
- Power systems shall be capable of 24/7/90 day operation before significant onboard maintenance.
- Molecular sieve materials must be fines removal pre-sieved then triple bagged with an appropriated desiccant for long-term on-board storage.
- PSA / VPSA or VSA must provide a 90%+ gaseous O2 product @ 2 bar pressure.
- PSA / VPSA or VSA must provide a 90%+ methane / CO2 blended product @ 2 bar pressure.
- PSA / VPSA or VSA must provide a 90%+ nitrogen product suitable for direct emission or other onboard uses such as fire suppression (insight).
- Power systems must be easily integrated and coupled / decoupled with existing onboard drive systems.
- Power system turbines should be two or more output shaft capable to provide flexibility in drive and onboard power system integration and / or repair while at work.
- Said power systems batteries must be capable of providing at least +100% of peak demand for a 1-hour span (insight).

- Power systems must be of unitized construction and capable of 4-hour changeout in depot (insight).
- Said systems must provide enough power for mission critical sub systems.
- Startup external power supply shall be capable of 10-minute deployment support.
- Ultracapacitor components shall be capable of multiple recharges from the battery outputs.
- Ultracapacitor components shall be provided suitable for startup and local or brief operational needs (insight).
- Ultracapacitor output shall be on board DC or AC voltage / amperage selectable (insight).
- Eddy current suspension and brake motors shall take power from on board high voltage batteries only (insight).
- On board batteries shall be capable of meeting stand-alone operation for not least than 2 hours of sustained operation (insight).
- Sustaining H2/O2 EGT combustion will require on-board compressed gaseous supply (insight).
- Keeping the on-board batteries charged as necessary so that the suspension and brake motors can demand respond is the EGT' normal goal (insight).
- Batteries to be LiON or better and capable of sustained operation.
- Eddy current regenerative braking systems including dielectric fluid cooling shall be integrated (insight).
- Eddy current suspension motors and suspension must be AC not DC to mitigate resistor heat issues.
- Traction motors shall use a vaporizable dielectric fluid for heating / cooling.

- Radiators for dielectric fluid cooling may be externally mounted on the locomotive or on the following cars by serial connection (insight).
- Heating / cooling of the cars shall be by radiator chilling or EGT heating of the non-hazardous dielectric fluid which may be palm oil or a derivative (insight).
- Alternatively, externally supplied compressed hydrogen shall be provided and supplied from an on-board tank of appropriate design.
- Said PSA (s) may be single but should be parallel installed for redundancy (insight).
- Inlets for the PSA's shall be face mounted into on-board compressor assemblies to feed the PSA MOF vessels (insight).
- All on-board process heat exhausts shall be vertical and common in a single stack.
- External control systems shall be optimized for both on time people and goods delivery at least cost and least risk.
- On board control systems shall include control and use of cooling / heating AC drive motor's dielectric fluid and continuous track monitoring for parallel spacing and displacement (insight).
- It shall have a 750-mile range maximum.
- No intermediate stops between entry and exit are foreseen.
- Current distance basis is centered on Los Angeles CA to San Francisco CA.
- It shall be limited to passengers, luggage, and small freight items like conventional air freight.
- Speed shall be not more than 0.95 - 0.98 mach at MSL with a partial vacuum.
- Speed limit is meant to avoid a shock wave.
- Speed modes shall be acceleration, cruise, and deceleration.

- Speed shall therefore be ~ 650 mph during cruise phase.
- Speed shall be during acceleration / deceleration not more than 1 G maximum on the horizontal plain.
- Technology limitations assume that system have two major components - capsule and tube.
- Tube is assumed to be partially evacuated to minimize both a bow wave and friction losses between tube and capsule.
- Tube assumed to be metallic in nature and very probably thin wall stainless steel.
- This author assumes that capsule atmospheric control is assumed to be self-contained for the flight's duration.
- This author assumes that passengers shall not have on board access to waste facilities.
- This author assumes that E-stop function has not been defined.
- This author sees E-stop as emergency stop that shall not exceed 1G maximum deceleration.
- This author sees E-stop portals to be hard ports in tube wall at known intervals with proper imbedded controls and that shall be easily accessed from tube inside and outside.
- This author sees capsule that shall have imbedded E-stop feature with cascading features such as tube pressure, capsule pressure, temperature and exit access proper interlocks.
- This author sees E-stop recovery shall be via remote control only.
- This author assumes that envisaged range is not a hard number and may be much shorter or much longer than 750 miles.

- This author proposes that E-stop deceleration may be imbedded but emergency only EGT assisted with directional nozzles suitable for a single time use from maximum speed and load in full atmosphere (insight).
- This author proposes that tube is not evacuated with propulsion provided via his HSR concept (insight).
- Alternatively, tube may be ground mounted concrete or composite tube with PRV's of sufficient diameter and radial spacing to prevent a bow wave at maximum velocity (insight).
- Eddy current braking shall be design standard and used to charge on board battery packs.
- Capsule shall be of largely non-ferromagnetic materials (insight).
- Tube shall integrate humidity controls spaced at defined intervals with water discharged outside tube (insight).
- Cassette type foamed metal heat sinks at each capsule end shall be used to manage both capsule interior and tube exterior temperature within a specified range (insight).
- Cassette type foamed metal heat sinks shall be removed after each trip passage or station and used as heat source for heat engine power generation or regeneration (insight).
- Emergency tube interior foamed metal heat sinks shall be spaced on the tube's exterior at routine intervals with appropriate tube exterior radiator of passive operation design (insight).
- Capsule interior atmosphere shall be maintained from EGT inlet compressor bypass (insight).

- Capsule shall have external surface mounted highly conductive linear accelerator bands meant to mesh effectively with external coilgun acceleration system (insight).
- Capsule exterior and tube interior shall use full diameter conductive external bands as "maglev" type suspension powered both by on board batteries and external cruise coilgun stations spaced at routine intervals on the tube exterior (insight).
- On board EGT exhaust may also power suspension nozzles during cruise or deceleration phases such as an E-stop or power outage condition (insight).
- Tube interior lighting may be provided during an E-stop condition via PRV normally open solenoid power loss condition (insight).
- Tube and all tube exterior appurtenances shall be full earth grounded during an E-stop event (insight).
- Capsule and tube dimensions and capacities shall be constrained by "maglev" type suspension requirements (insight).
- Tube seating shall have a vertical axis post suitable for two position orientation such as "forward" during entry, acceleration, and cruise and "rearward" during deceleration, exit and E-stop conditions (insight).

CY2040 STRATEGY FOR FREIGHT AIRCRAFT REV2.0

Publication Date: October 26, 2020

Synopsis

This report and its notes reflect a vision for freight aircraft that I developed in mid to late Fall of 2020. I wanted to investigate what an aircraft would look like when introduced in CY2040. By then, hydrocarbons would likely be in short supply, climate change would be in full swing but the need for air freight and transport would still exist albeit in much reduced volume.

This chapter reflects a two-part development cycle. I read and evaluated very easily 60+ research papers. I tried to keep the design concept as practical as possible.

Introduction

The early adoption and then more widespread use of novel energy sources that both save money and increase profitability is not a new idea for entrepreneurs, scientists and governments and is a goal they aspire to achieve. Everyone wants to innovate or create the latest big thing that pushes society forward toward a yet brighter future profitably. Most (not all) of them have been fully proven to work but then no one deploys them for use until a vested second- or third-party controls it. Even then they often make a minor investment to just catch and kill it. A cynical world view is useful when working with mature markets, I think.

Blowing up that paradigm and making it to market requires the use of easily adopted stepchange technologies that offer overwhelmingly least cost operation for least risk. This simple strategy certainly applies in the air transportation market just as it applies to most markets. In this instance this strategy encompasses using a highly efficient, naturally occurring, non-hydrocarbon energy source and other closely integrated design concepts that already exist but above all else, those that are simple and cost efficient to prove up and then deploy.

The strategy as outlined below and further captured in the associated summary notes could accomplish this societally vital task as apparently none have before. Answering "why" might be vital this point. Why – because we are in the grip of a global pandemic (likely to become a series) that has changed and largely disrupted our global economy in a staggeringly short period of time. Finding the way to recover our economy and its various supply chains while also conquering the likely series of pandemics and climate change becomes an obvious first order priority that rapidly becomes a global strategy. This global strategy could well use this author's modest work as outlined herein to positive effect as a portion of that strategy by allowing hydrocarbon free / no external fuel supply / no solar PV air transportation including freight for least cost / least risk.

A relevant perspective by others that I picked out of a recent "Foreign Affairs" article:

“Climate change is often described as a “wicked problem” meaning that it resists easy definition and defies conventional solutions. It transcends political boundaries and cannot be solved by a single country, but international governance is a weak substitute. It is a collective – action problem that demands a collective solution, but it has instead led to a great deal of finger pointing.” Also, “In short, humanity uses the atmosphere as a free dumping ground for pollutants, and deeply vested interests resist changing that.”

A sizeable resource and research publication library has been assembled and should be used accordingly if interest proves favorable.

Air transport has proven to be time efficient in the delivery of goods on a global basis. Making these goods (and people) delivery system yet more efficient and timely enough to capture a complementary least cost integration with high-speed rail and nextgen ocean transport requires use of robust, simple, and efficient design concepts that offers least cost and least risk. Going faster and higher with yet more tonnage on board isn’t a viable answer especially when our society is going through wrenching changes due to climate change, pandemics and increasing resource scarcity. This concept I am outlining can be proven up quickly and deployed very broadly to best effect. At least that is my belief.

The priority would be the development of a replacement air transport powergen and thrust system capable of sustained reasonably high-speed transit with little downtime. This powergen would be highly scaleable with modular units likely being developed in the 0.5 –15 MW-h (or much more) range. High amperage AC

(or DC) power would be available on a 24/7 basis for an integrated unit cost of ~ $300,000 – several million USD. Said units would comprise powergen w PSA, STOL/VTOL nozzles, battery pack and cruise impellers. It would also be capable of sustained operation in all climactic conditions with industry standard uptime and efficiency or much better. Commercial development monies can likely be provided by USDOE or USDOD grants. Once decently proven up the private sector could conduct the rollout for a very substantial profit.

Reiterating, the target application for this summary report is least cost power generation (powergen) for air transport needs that replaces the need for hydrocarbon combustion systems for propulsion and their other onboard uses.

This powergen system may also occasionally require a small volume of startup only dedicated compressed oxygen and hydrogen supplied by conventional means which are or can be made easily and widely available at depots worldwide.

Replacing conventional powergen and propulsion systems for a least cost, least risk powergen and propulsion system offers obvious benefits. Affording to do a large-scale program conversion of this type can be easily done using the energy tax model this author has outlined many times in the recent past.

The sun doesn’t have to shine, the wind doesn’t have to blow, and the people and goods get delivered in a timely manner and safely.

Concept

This power generation system will create its own fuels from atmospheric gases (hydrogen and oxygen) and then via a proven hydrogen / oxygen expanding gas combustion turbine directly coupled to a power generator that will, in turn, charge a dedicated bank of sized for the application batteries (think TeslaWall). Said batteries will supply the AC or DC local onboard needs including propulsion on a demand basis. The system can be designed for 24/7/365-day operation with the promise of uptime exceeding 99%.

The forms of “emission” from this power generation system would be excess to need heat as steam seen as a contrail during cruise conditions. Takeoff or other high-speed operations may see some small amounts of NOx emissions as well.

Avoiding power generation output issues that can vary substantially with both ambient temperature, elevation and humidity requires the use of a high alloy intercooled two or three or more compressor stage set of serially piped LOPR turbines with supplemental water injection as needed. I do also advocate that these turbine sets be installed in parallel multiples (probably two) to provide scaleable power and necessary backup working from an excess of caution.

An illustration of the basic process also with some notes by others is shown below.

An excerpt by others: Sanz, Wolfgang, Martin Braun, Herbert Jericha, and Max F. Platzer. "Adapting the Zero-Emission Graz Cycle for Hydrogen Combustion and Investigation of Its Part Load Behaviour." In *Turbo Expo: Power for Land, Sea, and Air*, vol. 49743, p. V003T06A020. American Society of Mechanical Engineers, 2016.

“PROCESS DESCRIPTION OF A GRAZ CYCLE PLANT FOR HYDROGEN COMBUSTION

Figure 1 shows the principle flow scheme of the Graz Cycle plant for hydrogen combustion, and Fig. 2 the associated temperature-entropy (T-s) diagram generated by the software IPSEpro. The plant is based on a proposal by Jericha [9] and consists basically of a high-temperature Brayton cycle and a low-temperature Rankine cycle – a combined cycle. The Brayton part consists of the combustion chamber (CC), the high-temperature turbine (HTT) and the compressors (C1/C2). The Rankine steam loop consists of the heat recovery steam generator (HRSG), high-pressure steam turbine (HPT), low pressure steam turbine (LPT), condenser, condensate pump, deaerator and finally the feed pump supplying high pressure water to the HRSG.

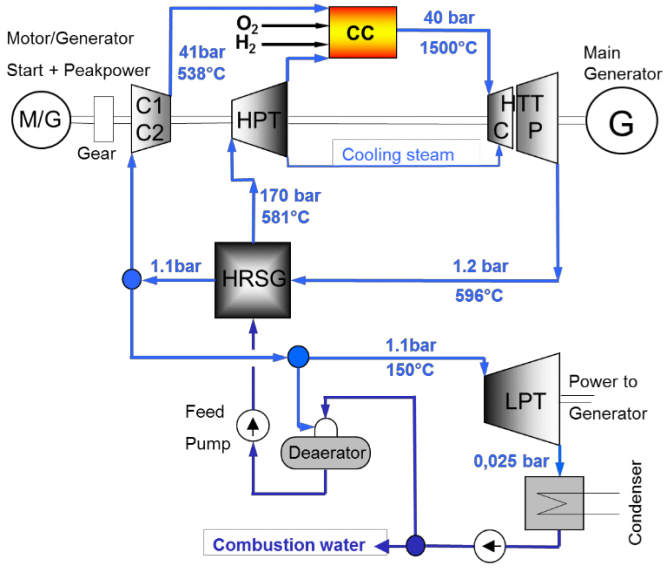


Fig. 1: Principle flow scheme of the Graz Cycle for hydrogen/oxygen combustion”

Maintaining consistent and predictable power generation is key for this process to work. The key is aggressive heat management as shown above.

Put another way: "Generally, unlike the heat rate, the net power output from a gas turbine decreases with an increase of the ambient air temperature. This is due to reduced net power output, which is directly proportional to the air mass flow rate; net power produced decreases when the ambient air temperature increases. Practically, a 25% loss of the rated power capacity of

the gas turbine at ISO conditions as the ambient temperature reaches 40 °C is reported."

Given that this process issue as described above can be easily overcome by design then this concept then becomes compelling given the application at hand.

In all instances all sub-systems are well proven. No new technology is required.

This author knows that a consistent and appreciable volume of relatively pure H2 / O2 are needed. My concept description for this is just below as both a simple drawing and in text (see next page):

A blower driven raw atmosphere intake contacts a set of three sequentially mounted molecular sieves that would remove [1]water vapor, [2]methane/carbon dioxide and [3]nitrogen from the intake atmosphere volume. The “concentrated” downstream “gas” would be 90%+ oxygen would be compressed in a storage tank and directly used in the combustion process.

Then the molecular sieve separated [2]methane/carbon dioxide would be purged or cleaned from its’ molecular sieve using a small volume of the compressed oxygen on a timed basis. The purged volume of methane/carbon dioxide/oxygen would be captured, compressed, and then processed at low pressure (<2bar) and ambient temperature through a photoelectrochemically powered tubular or sheet assembled, optically clear, covered methane “reformer” or “cracker” to make a compressed hydrogen and oxygen product with a small volume of residual of carbon dioxide as a contaminant. The [1]water vapor molecular sieve would be similarly purged with

the excess [3]nitrogen gas on a timed basis with the balance of the nitrogen vented to atmosphere.

Commercially this atmospheric gas separation can be described as a VSA, PSA or VPSA any of which could work. Commercial vendors for the appropriate molecular sieve materials and the gas separation systems exist and should be thoroughly explored and then used as appropriate.

Maintenance needs are expected to be very low and should require nearly or no skilled labor to operate.

Commercially this system will be attractive from both a cost to construct and use (deploy) perspective especially when compared to either conventional or other unconventional (renewable) energy systems.

Alternatively, if the onboard hydrogen supply is too small, compressed methane or natural gas could be used although this would assume that some form of on demand quality fuel logistic supply was available. If LNG or similar is not available, then compressed H2 may be used. Double wall monolithic austenitic SS tanks are the likely best choice. Said tanks may be fuselage mounted for ease of access and maintenance. Gaseous transfer pumps should likely be of ceramic design.

This author has previously specified use of magnetic bearings and transmissions for all applicable systems for similar, although smaller, applications. These are widely available and nicely sized for these applications which would eliminate most of the problems found with rotating machinery and their maintenance.

Again, as a sidebar statement, this author does advocate close integration with other renewable energy generation and storage systems to meet some takeoff or landing scenarios. This increases supply optionality in the event of a national and / or regional grid outage of significant duration.

Below is a simple summary chart of flight regime versus propulsion type for the envisioned air transport:

Flight Regime	EGT1 Subsonic	EGT1 Supersonic	EGT1 Turbo Impeller	EGT1 Battery Impeller
Takeoff:				
STOL	*			
VTOL		*		
Conventional			*	
Climb:				
Rapid		*		
Slow	*			
Conventional			*	
Cruise				
FR1				*
FR2			*	
Loiter				
Long			*	
Short				*
Conventional				*
Descent				
Rapid			*	
Gradual				*
Conventional				*
Landing				
STOL	*			

VTOL		*		
Conventional			*	
Arrested				*

Notes

- Goal 1: Nextgen +5 mixed use air transport prime mover is the innovation target for this effort.
- Goal 2: Nextgen +5 mixed use air transport prime mover must be capable of adoption within 15 years.
- Goal 3: Nextgen +5 mixed use air transport prime mover must be least cost, least risk.
- Goal 4: Nextgen +5 mixed use air transport prime mover' must be hydrocarbon combustion free.
- Goal 5: Nextgen +5 mixed use air transport prime mover must be robust for >1M mile service life.
- Goal 6: Nextgen +5 mixed use air transport must be capable of sustained 0.5 mach operation or slightly less operation in all climactic conditions.
- Goal 7: Nextgen +5 mixed use air transport must be operable in all topography's and climates.
- Goal 8: Nextgen +5 mixed use air transports must be capable of direct use of existing air transport signal and control systems as is with no modifications.
- A previously made point of value: "A concentrated gaseous methane driven to saturation via a gas / fluid venturi in a water matrix feedstock for Hypersolar's tech may represent some very valuable IP (Insight). The hydrogen generation would be a large multiple of water alone."

- Air freight must be limited to mission critical items only - otherwise HSR transport is required.
- Air transport fuselage shall be lifting body design optimized for efficiency reflecting least cost, least risk operation.
- Air transport shall be mixed use (people and freight) transport targeted designs optimized for least cost, least risk operation.
- Air transport sizing must be standardized.
- Air transport wings' aspect ratio shall be highly variable designed for efficiency reflecting least cost, least risk operation (Insight).
- All components must be capable of in place maintenance and replacement.
- All external power generated shall first charge on board batteries.
- All fuel pumps shall be of ceramic construction.
- All mission critical replacement components must be local stocked.
- All onboard control systems to be hardened 24VDC.
- All onboard power systems to be AC (or DC with debate).
- All weather, any time operation is another key operating parameter.
- Alternatively, externally supplied compressed hydrogen shall be provided and supplied from an on-board fuselage tank of appropriate design.
- Alternatively, hydrogen may be solar reformed from a methane concentrate from a sequentially MOF configured on-board PSA (Insight).
- Atmospheric emissions shall be low temperature water vapor and trace amounts of NOx and CO2 well below background levels (Insight).
- Batteries to be LiON or better and capable of sustained operation.
- CO2 sequestration for this application is contraindicated.

- Cruise altitude likely 10 - 15K above MSL and will not need passenger oxygen (Insight).
- Cruise range will be nearly unlimited (Insight).
- Cruise to be trailing edge electric turboprop.
- Deployment of said system into full operation shall not be more than five minutes from a dead start with charged batteries (Insight).
- Design by materials and function to be MilSpec "stealthy".
- During cruise state there will be no cruise heat emissions per se (Insight).
- EGT exhaust heat can be used for environmental control of batteries and indirectly the motors on a pass / bypass basis (Insight).
- External control systems shall be optimized for both on time people and goods delivery at least cost and least risk.
- Freight / luggage / munitions must be modular sections insertable into a "freight bay" (Insight).
- Gas storage and supply tanks shall be of double walled monolithic stainless steel with vacuum isolation.
- Gaseous methane and entrained but not required CO2 within an optically clear shell and tube arrangement (Insight) with an explanation:
- H2/O2 expanding gas turbine power generation must be capable of supplying all on board power needs plus at least 25% of peak demand into the on-board storage battery / ultracapacitor banks.
- H2/O2 heat recovery shall be recycled for pre-heat and methane reformer needs then vented to atmosphere.

- Heating / cooling of the fuselage shall be by radiator chilling or EGT heating of the non-hazardous dielectric fluid which may be palm oil or a derivative (Insight).
- If VTOL or STOL landing strips are not practical, then landing and takeoff can be LOPR / turboprop.
- Impeller shrouds ID may be most efficient PSA inlet via micropores (Insight).
- Liquid water (sheet or tube (Insight) configured)) as per https://hypersolar.com/
- Liquid water with saturated dissolved methane (Insight).
- LOPR exhaust to be VTOL/STOL design but reflecting the least cost, least risk design basis it will likely be STOL only (Insight).
- LOPR to be composite / ceramic construction and must be modular of a common size.
- Max speed will likely be 0.5 mach.
- Methane cracker can be used as a fuel source:
- Methane cracker must be capable of providing at least a 50%+ hydrogen product @ 2 bar pressure (Insight).
- Molecular sieve materials must be fines removal pre-sieved then triple bagged with an appropriated desiccant for long-term on-board storage.
- Motors must be AC not DC (debate possible) to mitigate resistor heat issues.
- Motors shall take power from on board high voltage batteries only (Insight).
- Motors shall use a vaporizable dielectric fluid for heating / cooling both within the powergen system as well as the fuselage.
- Multi pilot cockpit must be a design standard.
- Munitions may be carousel launched from said module (Insight).

- Nextgen air travel assumes close integration with mixed high-speed rail both meant to mitigate any need for hydrocarbons and still provide superior service and delivery (Insight).
- On board batteries and their LOPR EGT power source to be dielectric fluid cooled / heated (Insight).
- On board batteries shall be capable of meeting stand-alone operation for not less than 2 hours of sustained operation (Insight).
- On board control systems shall include control and use of cooling / heating AC drive motor's dielectric fluid (Insight).
- On board H2/O2 concentration via PSA ala F-35 as a concept but not for cabin / passenger uses (Insight).
- On board H2/O2 low OPR (LOPR) expanding gas combustion turbine(s) with no visible inlet shall be wing or tail mounted optimized for efficiency reflecting least cost, least risk operation (Insight).
- On board H2/O2 low OPR (LOPR) expanding gas combustion turbine(s) may also have an irised (normally closed) inlet of such diameter and geometry to provide supplemental air for the LOPR for takeoff and other high speed operating regimes (Insight).
- On-board hydrogen generation shall be by incident solar reforming (previous – by author) serially mounted on the trailing cars roofs and / or the locomotive (Insight).
- On-board oxygen may be supplied from the incident solar reforming system as a product or more preferentially from a PSA supplied concentrated product (Insight).

- Onboard AC /HVAC needs qualify for integration with a 6 - 10% inversion penalty.
- Power system turbines should be two or more output shaft capable to provide flexibility in drive and onboard power system integration and / or repair while at work.
- Power systems must be capable of 99%+ uptime operation with planned PM only.
- Power systems must be capable of sustained stand down or storage - on the order of years with no penalty (Insight).
- Power systems must be easily integrated and coupled / decoupled with existing onboard drive systems.
- Power systems must be fully capable of offline no external access (Insight).
- Power systems must be of unitized construction and capable of 4-hour changeout in depot (Insight).
- Power systems shall be capable of 24/7/90 day operation before significant onboard maintenance.
- Prime mover' shall be hydrogen / oxygen EGT / electric motor design to provide thrust and / or drive impellers.
- PSA / VPSA or VSA must provide a 90%+ gaseous O2 product @ 2 bar pressure.
- PSA / VPSA or VSA must provide a 90%+ methane / CO2 blended product @ 2 bar pressure.
- PSA / VPSA or VSA must provide a 90%+ nitrogen product suitable for direct emission or other onboard uses such as fire suppression (Insight).
- Regenerative braking must be a design standard.

- Regenerative braking systems including dielectric fluid cooling shall be integrated (Insight).
- Regenerative turboprop shaft rotation using REM's for battery charging (Insight).
- Roller extensible fabric wings and ailerons actuation via CNT composite flexible linear actuators as a key design parameter (Insight).
- Said power systems batteries must be capable of providing at least +100% of peak demand for a 2-hour span (Insight).
- Said PSA (s) may be single but should be parallel installed for redundancy (Insight).
- Said systems must provide enough power for mission critical sub systems.
- Speed or least transit time is not a key operating parameter.
- Spray applied silica hydrogel shall be used to insulate gas supply tanks and batteries and will also provide a measure of stealth capability.
- Startup external power supply shall be capable of 10-minute deployment support.
- Stealthy design with construction materials to be 98%+ composites with wings and other control surfaces to possibly be high tensile fabric (Insight).
- Sustaining H2/O2 EGT combustion will require on-board compressed gaseous supply (Insight).
- Take off / landing to be LOPR powered “jet” capable of sustained max thrust for 30+ minutes.
- The air transports’ propulsion concept shall be a hybrid turbine / electric concept.
- Turboprops to be composite only with low tip speeds.

- Turboprops to be shrouded with winglets.
- UAS / UAV variants should be a "stand in" for military needs (Insight).
- Ultracapacitor components shall be capable of multiple recharges from the battery outputs.
- Ultracapacitor components shall be provided suitable for startup and local or brief operational needs (Insight).
- Ultracapacitor output shall be on board DC or AC voltage / amperage selectable (Insight).
- Uptime, least cost, least risk operation is the key operating parameter.

N+5 SCRAMJET IDEAS REV1.0

Publication date: July 20, 2020

Synopsis

In Mid 2020 I had still some hope that I might return to gainful work with at worst another government contractor. Accordingly, I had been investigating novel methods of high-speed travel both in atmosphere and ex atmosphere. My research revealed that some progress had been made toward hypersonic in atmosphere flight, but little detail was available as I expected.

Using available information, I extrapolated what I thought a scramjet might look like as well as its materials of construction and possible flight modes. I did have some insights that I thought might be useful as well.

Some may find this an interesting read. I hope that some do so.

Introduction

The early adoption and then more widespread use of novel energy sources that both save money and mitigate risk is not a new idea for entrepreneurs, scientists and governments and is a goal they aspire to achieve. Everyone wants to innovate or create the latest big thing that pushes society forward toward a yet brighter future profitably. Most (not all) of them have been fully proven to work but then no one deploys them for use until a vested second- or third-party controls it. Even then they often make a minor investment to just catch and kill it. A cynical world view is useful when working with vested markets, I think.

Blowing up that paradigm and making it into widespread use requires easily adopted stepchange technologies that offer overwhelmingly least cost operation for least risk. This simple strategy certainly applies in the air transportation market just as it applies to most markets. In this instance this strategy encompasses using a highly efficient, naturally occurring, non-hydrocarbon energy source and other closely integrated design concepts that already exist, with some twists in perception and execution, but above all else those that are simple to prove up and cost efficient to deploy. It would also help solve the issue of unstart and speed maintainance at high mach numbers quite readily I believe.

A sizeable resource and research publication library has been assembled and should be used accordingly if interest proves favorable.

Air transport has proven to be time efficient in the delivery of goods on a global basis. Making these goods (and people) delivery system yet more efficient and timely enough to capture a complementary least cost integration with both high-speed rail and nextgen ocean transport requires use of robust, simple, and efficient design concepts. But going faster and higher with yet more tonnage on board isn't necessarily a viable answer when existing designs seem to be high risk, high cost, single shot solutions.

Accordingly, answering these issues and to answer increasing military and ex-atmosphere needs is an issue that this simple paper might help solve.

Further, this concept I am outlining can be proven up quickly and deployed very broadly to best effect. At least that is my belief.

Once decently proven up by USDOD or other interested parties, the private sector could conduct the rollout for a very substantial profit I would expect, making it attractive to all parties.

Reiterating, the target application for this summary report is least cost, reusable, least risk power generation (powergen) for hypersonic flight craft needs.

As a kindly meant sidebar note: Affording to do a large-scale program prove up of this type can be easily done using the energy tax model this author has outlined many times in the recent past.

Above all else, the sun doesn't have to shine, the wind doesn't have to blow, and the goods and maybe people get delivered in a timely manner safely.

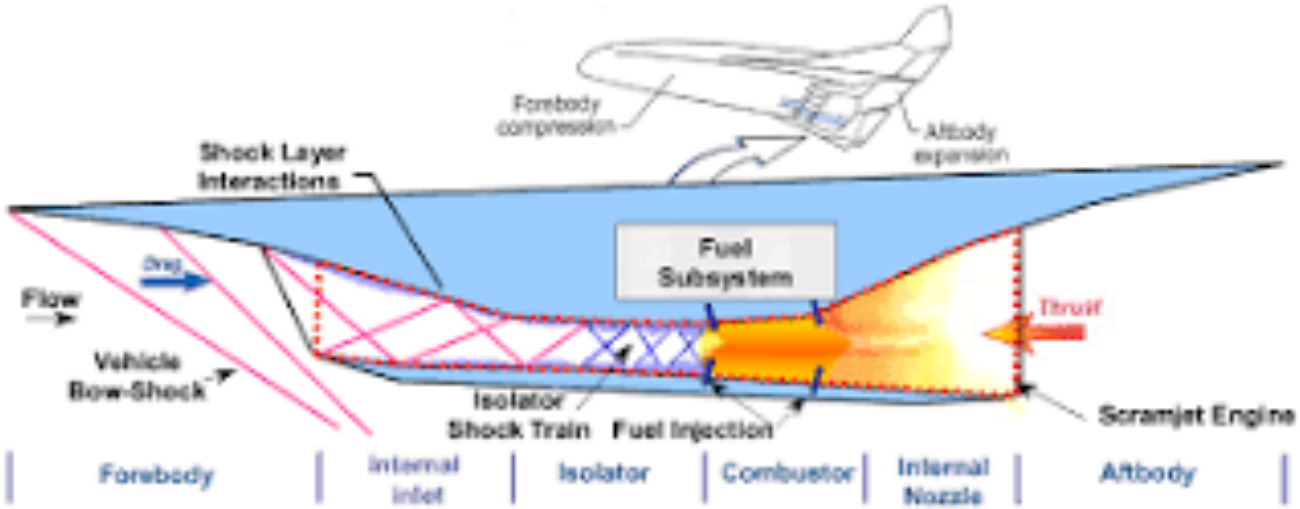
Concept

This power generation system for a ramjet or scramjet will create its own fuels from atmospheric gases (hydrogen and oxygen) and then via a proven hydrogen / oxygen no moving parts expanding gas "rocket" system.

The following is a reasonable description of a scramjet done by others a link [Wikipedia - Scramjet]

"A **scramjet** (**supersonic combustion ramjet**) is a variant of a ramjet airbreathing jet engine in which combustion takes place in supersonic airflow. As in ramjets, a scramjet relies on high vehicle speed to compress the incoming air forcefully before combustion (hence *ram*jet), but whereas a ramjet decelerates the air to subsonic velocities before combustion, the airflow in a scramjet is supersonic throughout the entire engine. That allows the scramjet to operate efficiently at extremely high speeds."

A diagram of its engine and packaging is below (by others as well but NASA I believe):



The forms of "emission" from this power generation system would be excess to need heat as steam seen as a contrail during cruise conditions. Emissions may also have some low-level NOx.

Maintaining consistent and predictable power generation in all operating regimes is key for this to work. The key seems to be aggressive heat management and the ability of inject variable amounts of pure or nearly pure gases which has been largely conquered by others through past work.

Commercial vendors for the appropriate molecular sieve (MOF) materials and the gas separation systems exist and should be thoroughly explored and then used as appropriate.

Maintenance needs are expected to be very low and should require nearly or no skilled labor beyond that currently in use to operate.

Notes

- Goal 1: Nextgen +5 scramjet is the innovation target for this effort.
- Goal 2: Nextgen +5 scramjet must be capable of adoption within 25 years.
- Goal 3: Nextgen +5 scramjet must be least cost, least risk.
- Goal 4: Nextgen +5 scramjet must be hydrocarbon combustion free.
- Goal 5: Nextgen +5 scramjet must be robust for >0.1M mile service life.
- Goal 6: Nextgen +5 scramjet must be capable of sustained +10 mach operation or more operation in all climactic conditions.
- Goal 7: Nextgen +5 scramjet must be deployable and operable in all topography's and climates.
- Goal 8: Nextgen +5 scramjet must be capable of direct use of existing air transport signal and control systems as is with no modifications.
- Ramjets and scramjets are useful militarily but not commercially.
- Commercial flight requires scaled fuselage and aerodynamics which are not possible now or even in N+5.
- The concept of lessening or eliminating on board fuel requirements is attractive.

- Aerodynamics and control of a hypersonic, high altitude atmospheric flight vehicle is difficult.
- Stratosphere and Mesosphere molecular physics are still largely unknown.
- Ionic oxygen and ozone will be an issue at high altitudes especially as a fuel accelerant.
- This author proposes that on-board MOF separation of N2 (maybe O3) from inlet gases would be advantageous and would be beneficial enrichment for O2 etc (Insight).
- Continuous "bleed" of N2 and ozone "overboard" would be advantageous (Insight).
- Compressed or cryogenic H2 onboard would be advantageous for high altitude combustion (Insight).
- Slush hydrogen makes no sense for this scale vehicle.
- Inlet for MOF N2 separation would be at inlet to "compressor" section (Insight).
- Reinjection of enriched O2 would be via micropore ring injection at entry to combustor (Insight).
- H2 injection would be like O2 injection.
- If provision is made for making and accumulating compressed O2/O1 onboard, then NEO or higher altitudes could be achieved (Insight).
- Powered re-entry would be similarly possible without orbital refueling.
- Lifting body design with retractable or variable control surfaces except rudder would be desirable.
- Vehicle transport to mesosphere may be possible by combined cycle reusable rocket.

- Vehicle transport to stratosphere may be possible by "piggyback" on another larger aircraft.
- Vehicle transport to mesosphere may be possible by piggyback on a reusable EGT UAV larger profile cruise missile / transport.
- N2 sidestream could be compressed and used as an attitude thruster in NEO / LEO environments (Insight).

MICROGRID SCALED POWER AND WATER SOLUTION

Publication date: April 2020

Synopsis

I have long had a strong reason to believe that our national power grid may fail. Perhaps catastrophically, perhaps not. Early 2020 was certainly an uncertain time and I decided to investigate what a microgrid was and what it could be in what I suspected a climate challenged future would be.

I saw that a microgrid when properly installed would or could provide power, water and heat to a grid area comprising several hundred homes reliably.

Accordingly, I spent quite some time investigating what a consensus opinion for design might be and what I thought it practically could do. This report was the result.

Introduction

This MicroGrid scale power generation system will create its own fuels from atmospheric gases (hydrogen and oxygen) and then via a proven hydrogen / oxygen expanding gas combustion turbine drive to a coupled power generator that will charge a dedicated bank of sized for the application batteries (think TeslaWall). Said batteries will supply the DC local microgrid on a demand basis. Offgrid but still local demand would be dealt with using portable ultracapacitors mounted on this system for charging/recharging. The system should be designed for 24/7/90 day operation before first periodic maintenance.

System capacity can be made by design and supply variable based on locale and its conditions of use. Its capacity range could be well be 250 – 750 kWh of DC power with water supply likely to range from 10 – 150 gpm.

The forms of “emission” from this power generation system would be excess to need heat, water vapor, disinfected drinking water, nitrogen gas and a small volume of carbon dioxide gas which could be further dissolved in water and then properly reacted with lime to make a high-quality concrete – making Atmospheric

Carbon (AtmoC or DACC) removal is practical at a local scale if it proves desirable.

Avoiding power generation output issues that can vary substantially with both ambient temperature and humidity requires the use of a high alloy intercooled two or three or more compressor stage turbine with supplemental water injection as needed.

Put another way: "Generally, unlike the heat rate, the net power output from a gas turbine decreases with an increase of the ambient air temperature. This is due to reduced net power output, which is directly proportional to the air mass flow rate; net power produced decreases when the ambient air temperature increases.

Practically, a 25% loss of the rated power capacity of the gas turbine at ISO conditions as the ambient temperature reaches 40 °C is reported." This design

concept then becomes compelling given the likely deployment locales. These locales will be highly variable and its effective mitigation of power loss by design.

In all instances all sub-systems are well proven. No new technology is required.

A blower driven raw atmosphere intake contacts a set of three sequentially mounted molecular sieves that would remove [1]water vapor, [2]methane/carbon dioxide and [3]nitrogen from the intake atmosphere volume. The “concentrated” downstream “gas” would be 90%+ oxygen would be compressed in a storage tank and directly used in the combustion process.

Then the molecular sieve separated [2]methane/carbon dioxide would be purged or cleaned from its’ molecular sieve using a small volume of the compressed oxygen on a timed basis. The purged volume of methane/carbon dioxide/oxygen would be captured, compressed, and then processed at low pressure (<2bar) and ambient temperature through a photoelectrochemically powered tubular or sheet assembled, optically clear, covered methane “reformer” or “cracker” to make a compressed hydrogen and oxygen product with a small volume of residual of carbon dioxide as a contaminant. The [1]water vapor molecular sieve would be similarly purged with the excess [3]nitrogen gas on a timed basis with the balance of the nitrogen vented to atmosphere or be collected, compressed, and have the carbon dioxide similarly collected, compressed, and dissolved in the just previously mentioned reject water.

That “sparkling water” product would also make an excellent feedstock for reacting with lime to make concrete – albeit at a modest or local scale.

Commercially this atmospheric gas separation can be described as a VSA, PSA or VPSA any of which mechanical configurations could work. Commercial vendors for the appropriate molecular sieve materials and the gas separation systems exist and should be thoroughly explored and then used as appropriate.

Maintenance needs are expected to be very low and should require nearly or no skilled labor to operate.

Commercially this system will be attractive from both a cost to construct and use (deploy) perspective especially when compared to either conventional or other unconventional energy systems. This option would keep the lights on and electronics working and properly disinfected drinking water flowing.

Alternatively, if the hydrogen supply is too small, cylinder supplied methane could be used although this would assume that some form of on demand logistic supply was available.

Do not attempt a grid tie nor integrate any form of remote monitoring or control. This will preclude anything but a local hack attack.

This author has specified use of magnetic bearings and transmissions for all applicable systems. These are widely available and nicely sized for these

applications which would eliminate most of the problems found with rotating machinery and their maintenance.

In all instance's deployment is easy and only requires the use of a small team and hand tools and should take not more than 4 to completely deploy.

Again, this author does advocate close integration with other renewable energy generation and storage systems to increase supply optionality in the event of a national and / or regional grid outage of significant duration.

Finally, if desirable, offgas of water vapor, carbon dioxide and syngas can be collected, compressed, and intermingled with lime ($Ca(OH)_2$) to make an ideal feedstock for concrete making using the following reactions: $CO_2 + Ca(OH)_2 > CaCO_3 + H_20$; $CH_4 + 2O_2 > CO_2 + 2H_20$. Said concrete when mixed before a "set" with local sand, stone or other aggregates can be useful for a variety of needs but not least as vehicular and ballistic barriers.

Concept

The integrated system as conceptualized is meant to be packaged both within and on the top surface of forty foot (40'), properly reinforced, shipping containers. This author further sees that container as having a reinforced floor and roof sufficient to support the wet or dry static load loads anticipated.

Further, both container ends will have access doors sufficiently reinforced and hinged to provide extended wall supports. The walls of the unit would be also

hinged and be capable of movement 90 degrees from horizontal and be reinforced to support the photoelectrochemical methane cracker units or wind turbines or solar PV cells or all or neither as the application and locale demand. This author conceptually designed and published a renewable energy power generation unit for these same applications some months ago. Integration with that unit would be quite simple but would require several 40' containerized units. Power output would therefore be very scaleable for microgrid purposes.

All internal component sections, cells or modules should be both skid mounted and capable of removal or movement by wheelift or similar arrangement. Hoses, pumps, valves must be in common sizes and of common materials. Cordage, bolts/ nuts etc should be similarly sized. Do not assume anything will or can be field torqued to spec because it won't happen.

The container unit must therefore have an internal frame of welded in place rectangular steel stock suitable to handle both air and land transport to not only a single site but to many further sites over many years of operation. Wall mounted "powerwalls" or a similar battery or ultracapacitor technology must be wall mounted and be also capable of simple removal and replacement.

The MCP must be similarly robust and capable of sustained operation with minimal maintenance over many deployments or movements. A high $ value IP opportunity might exist if a diode clamped multi-input inverter can be proven up. It should eliminate significant controls issues associated with the differing DC source inputs and the driving need for a consistent DC output.

DC power external distribution is expected to be via hand or wheel mounted reels capable of several hundred feet to several thousand feet in length. At least 10 and preferably 50+ reels must be integrated. Cross connection fittings and suitable end plugs must be provided as well.

Notes

- All components must be capable of in place maintenance and replacement.
- All components or their associated critical duty items.
- All external power generated shall first charge on board batteries.
- All external power supplied shall be DC.
- All mission critical replacement components must be local stocked.
- All onboard control system to be 24VDC.
- All onboard power systems to be DC.
- Batteries shall be capable of distribution and load balancing.
- CO2 sequestration for these applications is contraindicated but can be done if desirable.
- Deployment of said system into full operation shall not be more than two hours.
- H2/O2 expanding gas turbine power generation must be capable of supplying all on board power needs plus at least 25% of peak demand into the on-board storage battery / ultracapacitor banks.
- EGT H2/O2 post combustion heat recovery shall be recycled for pre-heat the EGT inlet and for the methane reformer needs and then vented to

atmosphere using ceramic composite heat exchangers if potable water is already available.

- H2/O2 vent shall have provision for drinking water supply via spigot from a dedicated supply tank.
- H2/O2 water supply shall have on board NaOCl generation from table salt and dosing hardware for disinfection of the supply tank.
- Home or FOB AC sub systems do not qualify for integration.
- Gaseous methane or CO2 shall be photochemically reformed within an optically clear shell and tube arrangement (Insight) with an explanation:

> "A concentrated gaseous methane driven to saturation via a gas / fluid venturi in a water matrix feedstock for Hypersolar's tech may represent some very valuable IP. The hydrogen generation would be a large multiple of water alone."

- Microgrid power systems must be capable of fully autonomous operation.
- Microgrid power systems must be capable of sustained stand down or storage - on the order of years.
- Microgrid power systems must be fully offline.
- Microgrid power systems shall be capable of 24/7/90 day operation before significant maintenance.
- Molecular sieve materials must be fines removal pre-sieved then triple bagged with an appropriated desiccant for long-term on-board storage.
- PSA / VPSA or VSA must provide a 90%+ gaseous O2 product @ 2 bar pressure.

- PSA / VPSA or VSA must provide a 90%+ methane / CO2 blended product @ 2 bar pressure.
- PSA / VPSA or VSA must provide a 90%+ nitrogen product.
- Particle Swarm Optimization (PSO) is highly recommended to select siting location and sizing for these systems.
- Said power systems must be capable of providing at least +50% of peak demand for a 4-hour span.
- Said systems are a failsafe option only in the event of a grid failure.
- Startup external power supply shall be capable of two-hour deployment support.
- Ultracapacitor components shall be capable of multiple recharges from the battery outputs.
- Ultracapacitor components shall be provided suitable for offgrid needs.
- Ultracapacitor output shall be on board DC voltage / amperage selectable.
- Operation should be primarily manual with only modest temperature / bypass instrumentation.
- EGT exhaust heat can be captured and used as a heat source if needed for the Hypersolar' process needs (Insight).
- EGT offgas of water vapor, carbon dioxide can be collected, compressed, and intermingled to make an ideal feedstock for concrete making using the following reactions: $CO_2 + Ca(OH)_2 > CaCO_3 + H_20$; $CH_4 + 2O_2 > CO_2 + 2H_20$ (Insight).
- Sourcing $Ca(OH)_2$ or “lime” can be simple and easily stockpiled as useful for a variety of needs but not least for making on-site concrete which has many uses but not least as vehicular and ballistic barriers (Insight).

- This simple process addition does also and thereby remove atmospheric carbon albeit at a modest scale (Insight).

N+2 ATMOSPHERIC MOISTURE HARVESTING

First published: Friday, July 31, 2020
Final publication: Friday, August 14, 2020

Synopsis

This report took a surprising amount of work to properly investigate. At the time, at the height of the Covid 19 pandemic, I had (have) a strong reason to believe that locally manufactured atmospheric water or moisture harvesting could be of real benefit to many. That investigation bore fruit I think.

The following report summarizes my findings and emphasizes how simple and practical this could be with a modest development effort.

Introduction

Backyard or residential, microgrid and FOB (small military bases located overseas) scaled moisture harvesting from the air represents a way to provide potable water without infrastructure. It works in situation's that are water scarce such as an arid desert or places that are rapidly becoming a desert or in a location with no available potable water.

A new, novel, least cost / least risk method does exist to provide a solution to what is otherwise a major problem. This author advocates that this solution needs to be better developed targeting reducing the complexity of manufacture / chemistry for the MOF with CNT', PAM and CaCl2 imbedded within it. This should

be not too hard to prove up. It needs just a little time, some lab space and available talent.

A lengthy review of existing commercial systems and emerging technology left this author with but two paths that seem like they will work well for least cost and no risk. They are outlined below. Some overlap of the paths seemed inevitable or at least useful. I outlined that overlap as “large scale” in the summary notes section.

Further, explaining “why” moisture harvesting is useful this author leaves that to others’ that have said it better (but I will inject my own thoughts- author).

An excerpt from: Boretti, A., Rosa, L. Reassessing the projections of the World Water Development Report. *npj Clean Water* **2,** 15 (2019).

“Water, which is an essential part of life, has a rising global demand. This increase in demand is mainly due to increase in the world’s population, shifts in water consumption behavior and expansion of irrigated agriculture. This leads to water becoming more and more scarce. Only 2.5% of the water on earth is fresh water and only less than 1% is accessible fresh water. The increase in pollution (caused by increasing population and also by increasing agriculture- author) decreases the amount of accessible fresh water that can be consumed by humans.

The majority of the world’s population, who live in poverty, live in water-scarce regions such as the Middle East, sub-Saharan Africa and parts of Asia.

Water scarcity can be described as the mismatch between the water demand and water availability with demand being higher than availability (thus creating a scarcity condition – author). When demand and availability are almost equal, an increase or decrease in one of them could affect the scarcity level.

For example, the Arabian Desert suffers from water scarcity more than any other desert due to its high population density and its intense agriculture.

Furthermore, some areas, such as basins in India, Southern Africa and Australia,

experience countercyclical water availability. Countercyclical water availability means water consumption being at its highest when water availability is at its lowest. This countercyclical behavior results in a decrease in river flows and lake and groundwater levels. Lakes, such as the Chad Lake in Africa and the Aral Sea in Central Asia, are disappearing and countries, such as Saudi Arabia and China, are experiencing groundwater depletion.

Water scarcity is also affected by global warming, which affects water run-off, evaporation and precipitation. As the world's temperature increases by only 2C above its current level, up to one-fifth of its population could suffer from water shortages (desertification will be a major impact of climate change and is being seen now in the southwestern and midwestern USA – author).

That, subsequently, will increase the number of people around the world who would have to use less than 500 cubic meters of water per year by 40%, which is considered as 'absolute' water scarcity.

In terms of population, about 71% of the world's population lives in moderate water scarcity and 66% lives in severe water scarcity for at least one month a year. Put another way, 1.8 to 2.9 billion people live in severe water scarcity for four to six months a year. And half a billion people live in severe water scarcity throughout the entire year (this could be the case in the southwestern and midwestern USA within 20 years – author)."

Answering "what" and "how" to fully develop and package this novel moisture harvesting technology for least cost, least risk is the intent of this simple paper.

Background

Answering some basic questions about definitions for what a MOF, CNT, PAM, and a deliquescent salt such as CaCl2 (calcium chloride) will be helpful.

A relatively long excerpt from: Li, Renyuan, Yusuf Shi, Le Shi, Mossab Alsaedi, and Peng Wang. "Harvesting water from air: using anhydrous salt with sunlight." *Environmental science & technology* 52, no. 9 (2018): 5398-5406.

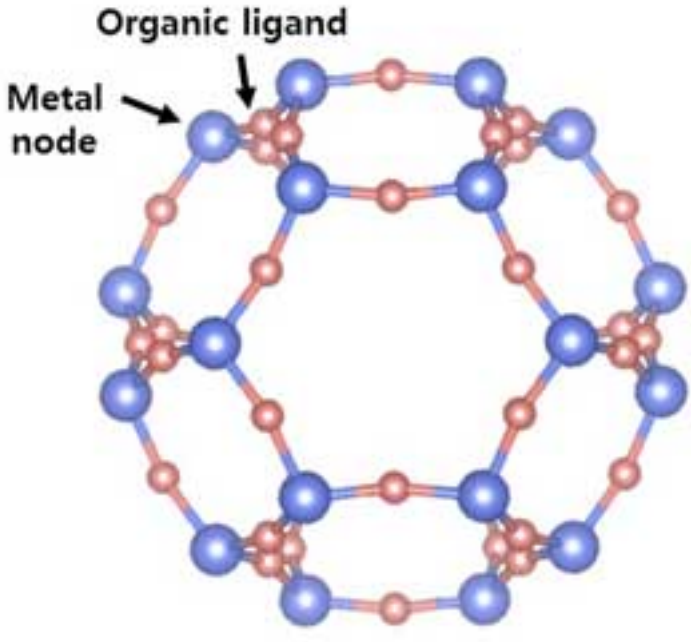
MOF:

“Metal-organic frameworks (MOFs) are organic-inorganic hybrid crystalline porous materials that consist of a regular array of positively charged metal ions surrounded by organic 'linker' molecules. The metal ions form nodes that bind the arms of the linkers together to form a repeating, cage-like structure. Due to this hollow structure, MOFs have an extraordinarily large internal surface area.

Researchers have synthesized MOFs that feature a surface area of more than 7000 square meters per gram. To put this into context, if you could lay out the available surface area in a teaspoon of this material (around a gram of solid), it would cover an entire soccer field.

MOFs offer unique structural diversity in contrast to other porous materials – uniform pore structures; atomic-level structural uniformity; tunable porosity; extensive varieties; and flexibility in network topology, geometry, dimension, and chemical functionality. This allows researchers the successful control of framework topology, porosity, and functionality.

MOFs unique structure design and tunability – crystalline porous materials that are composed of both organic and inorganic components in a rigid periodic networked structure – is not readily accessible in conventional porous materials, e.g., purely inorganic zeolites.



Schematic illustration of a metal-organic framework (MOF). The MOF, consisting of metal ions and organic ligands, is a highly porous material with an ultrahigh surface area. The various

structures of MOFs can be synthesized depending on the kinds of metal ions and organic ligands. (Image: KAIST)

By making the MOF from different metal atoms and organic linkers, researchers can create materials that selectively absorb specific gases into tailor-made pockets within the structure. MOFs therefore offer great potential for their effective integration and exploration in various sensing applications.

MOFs can be put together arbitrarily like Lego bricks and outperform every previously known class of material in terms of flexibility and uses."

In this application MOF's would be composed of alumina as the metal node and PAM as the organic ligand. Other metals and organic molecules are certainly available but from a cost and use perspective alumina and PAM are certainly widely available, functional, durable, and inexpensive. Therefore, they are certainly this authors' materials of choice for this application.

CNT:

"A carbon nanotube (CNT) is a molecular-scale structure consisting of carbon atoms arranged in one or more cylindrical layers, joined by covalent bonds in a hexagonal tiling pattern within each layer, so as to form a hollow tube up to a few hundred nanometer's in diameter. Carbon nanotubes are considered to be allotropes of carbon, intermediate between fullerene cages and flat graphene sheets (as in graphite).

A single-wall carbon nanotube (SWCNT) has a single cylindrical layer of atoms, comprising a single molecule, with diameter in the range of a nanometer.[1] A multi-wall carbon nanotube (MWCNT) may consist of two or more nested single-wall carbon nanotubes, joined mostly by weak inter-molecular forces;[1] or may be a single graphene-like sheet rolled up several times around a cylindrical hollow.[2] The term "carbon nanotube" has also been used, more generically, for carbon tubes with undetermined wall structure and diameters less than 100 nanometers."

CNT's in this application are a useful addition to the MOF's structure and should be largely integrated within the PAM organic ligand. Their function (at roughly a 0.05% concentration) is solely focused on absorbing incident UV light. Said absorption phenomenon increases the thermophotonic heating and release of the absorbed moisture or water molecule from the MOF's cage structure.

PAM:

Polyacrylamide (IUPAC poly(2-propenamide) or poly(1-carbamoylethylene), abbreviated as PAM) is a polymer ($-CH_2CHCONH_2-$) formed from acrylamide subunits. It can be synthesized as a simple linear-chain structure or cross-linked, typically using N,N'-methylenebisacrylamide (cross linked is the proper synthesis form – author).

In the cross-linked form, the possibility of the monomer being present is reduced even further. It is highly water-absorbent, forming a soft gel when hydrated, used in such applications as polyacrylamide gel electrophoresis, and can also be called ghost crystals when cross-linked, and in manufacturing soft contact lenses. In the straight-chain form, it is also used as a thickener and suspending agent. More recently, it has been used as a subdermal filler for aesthetic facial surgery (in this instance its ability to absorb water is key and crucial – author).

CaCl2:

"Hygroscopic and deliquescent materials are both able to absorb moisture from the air. However, hygroscopy and deliquescence don't mean precisely the same thing: Hygroscopic materials absorb moisture, while deliquescent materials absorb moisture to the extent that the substance dissolves in water.

Deliquescence refers to the property of a substance to absorb water from the air to dissolve itself and form an aqueous solution. Materials with this property are termed deliquescent. Deliquescent materials are a class of hygroscopic substances. Other types of hygroscopic materials may absorb water, yet not dissolve. In order to be deliquescent, a substance must both absorb a large amount of water and be sufficiently soluble to dissolve in it.

Most deliquescent substances are salts. Examples include sodium hydroxide, potassium hydroxide, ammonium chloride, gold (III) chloride, sodium nitrate, and **calcium chloride**. While table salt or sodium chloride (NaCl) may be deliquescent if the particles are small and the humidity is very high, salt is usually considered to be hygroscopic.

Because of their affinity for water, deliquescent substances find use as desiccants. They may be used to remove excess water from sulfuric and phosphoric acids. In the chemical industry, deliquescent chemicals are used to remove water from chemical reactions."

Hygroscopic materials do not readily release the moisture they absorb.

Deliquescent materials do readily release the water they absorb. Under certain conditions at the nanoscale – they very readily absorb water but do not dissolve.

Plus, they are also readily made to release the water under thermophotonic conditions such as strong sunlight and locally warm conditions. Making them ideal as a nanoscale moisture / water absorbent especially in an arid locale. Calcium chloride (CaCl2) makes for an ideal deliquescent salt for this application due to its relative availability and extremely low cost.

Concept

In a strong sense I am asking to find the way, by others, to develop a MOF that integrates CNT, PAM and CaCL2 within its structure. Current methods of manufacture are complex and require use of expensive hardware and solution chemistry to make. I advocate the use of ambient temperatures, commonly available solvents such as TCE or IPA or similar and hardware such as a solar or gas fired oven. CNT, unlike other previous uses where I have advocated aligned CNT does not need to be aligned for this application. The CNT' long dimension should be 5-6 nM in length and low nanometer diameter. This ask may seem like a very tall order, but I do think it can be done with an open mind and some perseverance.

Several very recent studies have been done that point the way. Not one of them offers an integrated recipe or formula to follow. I really don't understand why that might be the case but can certainly make a guess. The notes I've drafted regarding my own insights are below.

Also, and as importantly, I have tried to present volume scaled summary notes that are just below. My intent for small scaled installation is just to use unracked

one (1) to four (4) vessels hung vertically wherever its useful. I did NOT include this in my summary notes on purpose. Large installations will need to use a chilled venturi design and will need a source of power unfortunately unless the MOF tech is rack mounted and arrayed accordingly.

Notes:

- Solution blending / solvent blending is easiest approach to grow MOF and matrix / polymer "materials" (Insight).
- This approach will NOT grow a membrane such as a microfilter only an adsorbent matrix suitable for the application.
- The approach WILL grow an adsorbent matrix suitable for atmospheric moisture collection and release.
- MOF can be grown by thermal / solvent extraction.
- Solvent nucleation from alumina for MOF growth et al is desirable, better known as in-situ formation.
- PAM matrix growth is particularly simple and is also least cost / least risk.
- 5-6 nM CNT dispersed within the solvent bath with a dispersion agent such as a surfactant is desirable (Insight).
- CNT at roughly 0.05% / weight is highly desirable to promote extremely high irradiation efficiency during moisture / water recovery.
- CNT acid bath to promote hydrophilicity is contraindicated (Insight).
- Clear plastic (polyethylene) configured as an open topped cylindrical "bird feeder" with a funneled discharge spout is advantageous and desirable (Insight).
- Night collection with day discharge is the desirable operating condition.

- Continuous daily discharge is also advantageous.
- Specific loadings are dependent on vapor pressure, relative humidity and temperature but should approach 1:1 by weight of MOF / polymeric "material" on a sustained basis.
- Material will be use stable and capable of indefinite use.
- The discharge funnel shall be deeply ridged internally to mitigate surface tension issues that would arise with a smooth funnel.
- Disinfection may be desirable or routine flushing of "material" may be a reasonable substitute.
- Iodine or NaOCl pills may be desirable disinfection method for small volume bucket collections.
- Medium scale (100 - 500 gpd)
    - Inclined racks of MOF/CNT/PAM/CACL2 in 10x5 or 10x10 array commonly plumbed to single outlet.
    - Vessels to be squared with funneled and grooved discharge chute.
    - Array to be racked at 45 - 60-degree inclination with pivot to horizontal for ease of access (stalin's organ).
    - Disinfection to be manual / tabbed NaOCl in collection vessel.
    - Collection vessel(s) to be wheeled of clear or semi-opaque HDPE material and design with 2 - 3" opening w integral discharge spout.
    - Upper and lower aluminum plates for dust mitigation and direct UV protection or reflectance is desirable.
    - Hinged upper or inlet screening to prevent insect infiltration is desirable.

    - Operation may be continuous or overnight collection and daytime discharge.
- Large scale (500 gpd +)
    - Large scale (3m+ diameter) horizontal venturi w inlet fan and throat refrigerant coils and water discharge collection port.
    - Power to be either solar PV, wind, geothermal cooling or EGT or all four.
    - MOF/CNT/PAM/CaCl2) downstream scavenging in circular mat with single outlet discharge (2 total).
    - Disinfection to be NaOCl tabs or electrolytic salts (mentioned in a previous microgrid power / water report).
    - Venturi (s - any number) may be concrete or aluminum construction with exterior to be insulated.
    - Operation shall be overnight collection or continuous dependent on locale.

NEXTGEN CEMENT DEVELOPMENT

Published: Monday, May 4, 2020

Synopsis

My oldest son encouraged me to pursue this topic because, at the time, it seemed that our concept for concrete and its function and durability left a lot to be desired. I took him up on this encouragement and found out that yes, we still had a lot to learn, and hubris was keeping us from that knowledge.

I enjoyed writing this paper. More than most of my papers. My insights were certainly there, and I would have really enjoyed pursuing them to see which might be beneficial and those which would not.

Introduction

Concrete and its varied components have been used for infrastructure construction for 2,500+ years with varying levels of success. The Roman Empire innovated a hydraulic concrete formula that worked for their infrastructure needs especially well and those infrastructure works are still in use today – 2,500 years later. Our own contemporary formula's do not typically work as well and last for roughly 30 – 100 years. Answering "what", "why" and "how" to relearn this apparent lost technology and allow our modern infrastructure needs to capture the longevity of the old formula using contemporary components for least cost, least risk is the intent of this simple paper.

Background

Answering some basic questions about definitions for what concrete is and distinctions for its components that are in common use (by others).

An excerpt from: Hossain, Khandaker M. Anwar. "Properties of volcanic pumice based cement and lightweight concrete." *Cement and concrete research* 34, no. 2 (2004): 283-291. Plus, also: Hydraulic Cements

"Definition of concrete, hydraulic cement, mortar, and grout

Q. What are concrete, hydraulic cement, mortar, and grout?

A. *Concrete* is a composite material that consists of a mixture of hydraulic cement, aggregates, and water, with or without admixtures, fibers, or other cementitious materials.
Hydraulic cement is cement that sets and hardens by chemical reaction with water (hydration) and is capable of doing so under water (ACI 225R). The hydration reactions result in the formation of a hard-solid mass. The most widely used hydraulic cement is Portland cement. Other kinds of hydraulic cement include blended cements and ground granulated blast-furnace slag (ACI 233R). Pozzolans, both natural (ACI 232.1R) and artificial (fly ash, ACI 232.2R, and silica fume, ACI 234R) are often used as a cementitious ingredient of concrete.
Mortar is a mixture of cement paste and fine aggregate; in fresh concrete, the material occupying the interstices among particles of coarse aggregate; in masonry construction, joint mortar may contain masonry cement, or may contain hydraulic cement with lime (and possibly other admixtures) to afford greater plasticity and workability than are attainable with standard Portland cement mortar.
Grout is a mixture of cementitious materials and water, or other binding medium, with fine aggregate.

References: SP-1(02); CT-18; ACI 225R-19; ACI 233R-03; ACI 232.1R-12; ACI 232.2R-03; ACI 234R-06; E-1(16); E3-13
Topics in Concrete: Concrete Fundamentals; Grout; Materials"

Then answering the question of "why" modern concrete fails so badly (by others):

The cracks are starting to show. Dean McCartney, Author provided

The problem with reinforced concrete

June 17, 2016, 1.18am EDT

Author

1. **Guy Keulemans**
   Lecturer, UNSW

Disclosure statement

Guy Keulemans does not work for, consult, own shares in or receive funding from any company or organization that would benefit from this article and has disclosed no relevant affiliations beyond their academic appointment.

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By itself, concrete is a very durable construction material. The magnificent Pantheon in Rome, the world's largest unreinforced concrete dome, is in excellent condition after nearly 1,900 years. And yet many concrete structures from last century – bridges, highways and buildings – are crumbling. Many concrete structures built this century will be obsolete before its end.

Given the survival of ancient structures, this may seem curious. The critical difference is the modern use of steel reinforcement, known as rebar, concealed within the concrete. Steel is made mainly of iron, and one of iron's unalterable properties is that it rusts. This ruins the durability of concrete structures in ways that are difficult to detect and costly to repair.

While repair may be justified to preserve the architectural legacy of iconic 20th-century buildings, such as those designed by reinforced concrete users like Frank Lloyd Wright, it is questionable whether this will be affordable or desirable for the vast majority of structures. The writer Robert Courland, in his book Concrete Planet, estimates that repair and rebuilding costs of concrete infrastructure, just in the United States, will be in the trillions of dollars – to be paid by future generations.

Old bridges need new money to replace. Phil's 1stPix/Flickr.com, CC BY-NC

Steel reinforcement was a dramatic innovation of the 19th century. The steel bars add strength, allowing the creation of long, cantilevered structures and thinner, less-supported slabs. It speeds up construction times, because less concrete is required to pour such slabs.

These qualities, pushed by assertive and sometimes duplicitous promotion by the concrete industry in the early 20th century, led to its massive popularity.

Reinforced concrete competes against more durable building technologies, like steel frame or traditional bricks and mortar. Around the world, it has replaced environmentally sensitive, low-carbon options like mud brick and rammed earth – historical practices that may also be more durable.

Early 20th-century engineers thought reinforced concrete structures would last a very long time – perhaps 1,000 years. In reality, their life span is more like 50-100 years, and sometimes less. Building codes and policies generally require buildings to survive for several decades, but deterioration can begin in as little as 10 years.

Many engineers and architects point to the natural affinities between steel and concrete: they have similar thermal expansion characteristics, and concrete's alkalinity can help to inhibit rust. But there is still a lack of knowledge about their composite qualities – for example, in regard to sun-exposure-related changes in temperature.

The many alternative materials for concrete reinforcement – such as stainless steel, aluminium bronze and fibre-polymer composites – are not yet widely used. The affordability of plain steel reinforcement is attractive to developers. But many planners and developers fail to consider the extended costs of maintenance, repair or replacement.

Cheap and effective, in the short term at least. Luigi Chiesa/Wikimedia Commons, CC BY-SA

There are technologies that can address the problem of steel corrosion, such as cathodic protection, in which the entire structure is connected to a rust-inhibiting electric current. There are also interesting new methods to monitor corrosion, by electrical or acoustic means.

Another option is to treat the concrete with a rust-inhibiting compound, although these can be toxic and inappropriate for buildings. There are several new non-toxic inhibitors, including compounds extracted from bamboo and bacterially derived "biomolecules".

Fundamentally, however, none of these developments can resolve the inherent problem that putting steel inside concrete ruins its potentially great durability.

The environmental costs of rebuilding

This has serious repercussions for the planet. Concrete is the third-largest contributor to carbon dioxide emissions, after automobiles and coal-fuelled power plants. Cement manufacturing alone is responsible for roughly 5% of global CO_2 emissions. Concrete also makes up the largest proportion of construction and demolition waste, and represents about a third of all landfill waste.

Recycling concrete is difficult and expensive, reduces its strength and may catalyse chemical reactions that speed up decay. The world needs to reduce its concrete production, but this will not be possible without building longer-lasting structures.

Rebar reclamation: an expensive job. Anna Frodesiak/Wikimedia Commons

In a recent paper, I suggest that the widespread acceptance of reinforced concrete may be the expression of a traditional, dominant and ultimately destructive view of matter as inert. But reinforced concrete is not really inert.

Concrete is commonly perceived as a stone-like, monolithic and homogeneous material. In fact, it is a complex mix of cooked limestone, clay-like materials and a wide variety of rock or sandy aggregates. Limestone itself is a sedimentary rock composed of shells and coral, whose formation is influenced by many biological, geological and climatological factors.

This means that concrete structures, for all their stone-like superficial qualities, are actually made of the skeletons of sea creatures ground up with rock. It takes millions upon millions of years for these sea creatures to live, die and form into limestone. This timescale contrasts starkly with the life spans of contemporary buildings.

Steel is often perceived to be inert and resilient too. Terms such as “Iron Age” suggest an ancient durability, although Iron Age artefacts are comparatively rare precisely because they rust. If construction steel is visible, it can be

maintained – for instance, when the Sydney Harbour Bridge is repeatedly painted and repainted.

However, when embedded in concrete, steel is hidden but secretly active. Moisture entering through thousands of tiny cracks creates an electrochemical reaction. One end of the rebar becomes an anode and the other a cathode, forming a "battery" that powers the transformation of iron into rust. Rust can expand the rebar up to four times its size, enlarging cracks and forcing the concrete to fracture apart in a process called spalling, more widely known as "concrete cancer".

Concrete cancer: not pretty. Sarang/Wikimedia Commons

I suggest that we need to change our thinking, to recognise concrete and steel as vibrant and active materials. This is not a case of changing any facts, but rather of re-orientating how we understand and act on those facts. Avoiding waste, pollution and needless rebuilding will require thinking well beyond disciplinary conceptions of time, and this is especially true for the building and construction industries.

The collapsed civilisations of the past show us the consequences of short-term thinking. We should focus on building structures that stand the test of time – lest we end up with hulking, derelict artefacts that are no more fit for their original purpose than the statues of Easter Island."

Concept

Capturing the high performance (tensile, compression and deformation strength) of the Roman Empire's hydraulic cement matrix which cured readily in saltwater and capturing our current society's need for a terrestrial and marine cement ability can seem hard to do because nobody's apparently come close.

In a strong sense I am asking to find the way to increase our version of concrete's strength using commonly available components and I also do not want to use reinforcing rod (re-rod) steel because of its corrosion issues. A very tall order but I do think it can be done with an open mind and some perseverance.

Several very recent studies have been done that point the way. Not one of them offers an integrated recipe or formula to follow. I really don't understand why that might be the case but can certainly make a guess.

I've assembled a "recipe" with some broad instructions that should be helpful (I hope so). Not least the recipe will yield a cement matrix that will perform at least as well as today's cement. I strongly suspect it will outperform it and may well offer a least cost, least risk solution along with my own take on IP that might be captured as well.

Notes

- Aligned carbon nanotubes should be used - whether MW or SW will make no difference (Insight).
- Quicklime (CaO) shall be used as the hydrated cement' primary binder.
- Water shall be used as the hydration agent.
- Aluminum shall be used as a water supplement to promote tobermorite formation as sodium aluminum phosphate (Insight).
- Water shall not be softened (Insight).
- Water as the matrix or hydration agent or solution shall be alkaline and preferably with a pH of 8 +/- 0.5 in its initial state before any blending (Insight).
- Water shall be visually free of organic contaminants.
- Alignment of carbon nanotubes shall be done by mechanical mixing in water after the surfactant addition (Insight).
- Carbon nanotubes shall be added in the range of 0.1 - 0.5% by overall weight of the final mixture and preferably in the 0.1 - 0.25% range (Insight).
- Dispersion of the carbon nanotubes (CNT) shall be accomplished by inducing hydrophilicity of the CNT with a small, applied voltage of 2.0V to the initial water / CNT mix with phase and wattage not important (Insight).
- Alignment of the CNT in the initial water mix must be done by mechanical mixing until visually thoroughly dispersed (Insight).
- Use of oxidized calcium sulfate as an additive to the cement binder' dry blend is contraindicated (Insight).
- The soluble aluminum salt as sodium aluminum phosphate shall be added to the initial water blend before the CNT addition (Insight).

- Aggregate type and size used shall be to common standard.
- Aggregate used must be pre-washed until free of visible dirt and organic contaminants and then blended into the cement binder.
- Use of a non-ionic surfactant should be added to manufacturer' specification before the addition of the aluminum salt and CNT to the water matrix solution (Insight).
- Concrete cure time will be to industry standard for time and temperature.
- Mechanical performance shall be like hydraulic concrete or better without the need for continuous wetting unless in an arid climate (Insight).
- Otherwise, industry standards for mix blends and mixing time and energy shall not change.
- Water soluble iron salts such as iron sulfate or thirdly ferrous iron may be used as a substitute for calcium aluminum phosphate in extraordinary circumstances such as extremely arid or near vacuum environments (Insight).

CONCLUSION

I hope that those of you who read this book enjoyed it. I enjoyed writing it even if it originally was only comprised of 19 or so topical summary reports. If you didn't enjoy it or hated it, I apologize. No offense was intended.

A second and shorter book will also shortly be published. It will be entitled "Integrated Intermodal Freight and Transport". I have mentioned this previously. It seems like a logical finale.